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ABSTRACT

This curriculum guide is intended to train trade and industrial education students in the hands-on aspects of the occupation of machinist. Included in the guide are course outlines that deal with the following topics: following safety procedures; performing mathematical calculations; designing and planning machine work; performing precision measurement and bench work; operating drill presses, grinders, power saws, lathes, milling machines, and shapers; welding; performing heat treatment tasks; and operating numerical controlled machines. Each course outline contains some or all of the following: a duty; a task statement; a performance objective and performance guide; suggested learning activities; a list of recommended resources; student evaluation criteria, including answers to any evaluation questions or exercises provided; a lesson test, test answers; and attachments (including handouts, forms, and transparency masters). Appendixes to the guide include definitions of terms, duty and task and tool and equipment lists, evaluation questions and answers, and a bibliography. (MN)

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V-TECS GUIDE
FOR
MACHINE SHOP
(machinist)

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ACKNOWLEDGMENTS

The Machine Shop V-TECS Guide was developed from the Machinist V-TECS Catalog by a committee of Machine Shop instructors in South Carolina. These instructors are to be commended for their expertise in the field and for their ability to complete the tedious work required in developing this V-TECS Guide. The writers are: Johnny David (Hartsville Career Center), John Burris (Anderson District I and II Vocational Education Center), and Horace Hilderbrand (Aiken County Vocational Center). Another contributor who had to withdraw from the project was Kenneth Collins (R. D. Anderson Area Vocational Center).

The blueprint sketches were drawn by Chris Johnson, a student at Aiken County Vocational Center, Aiken, South Carolina.

The State Office of Vocational Education staff members who assisted the committee were Joe Bunn (T & I Consultant) and Dr. Annie Winstead (Sex Equity Consultant). Other staff members who were involved with the project were Pat Kinsey (Editor) and Jim Lewallen (Work Processing Operator).

Upon completion of the writing of the Machine Shop V-TECS guide, six educators were selected to field review the materials for validity and reliability. These educators are to be commended for their thoroughness in providing their expertise in modifying and approving this guide for classroom use. The field reviewers are: Gordon Gang (Aynor-Conway Career Center); Lewis Lanier (Clinton High School); John Pace (Oconee Vocational Center); Sam Picklesimmer (McDuffie High School); Elmer Richards (Wilson Vocational Center); and Frank Russell (Greenwood Area Vocational Center).

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INTRODUCTION

V-TECS guides are an extension or continuation of the V-TECS catalogs. While the V-TECS catalog is a composition of duties, tasks, performance objectives, and performance guides, it deals only with the psychomotor aspect of an occupation. It is a blueprint of an occupation. It deals only with the identification of the hands-on aspect of the occupation. It does not take into consideration such things as the background information surrounding a task, how to make inferences, generalizations and decisions from a body of knowledge, nor does it deal with attitudes, job seeking skills, safety or energy conservation practices. V-TECS guides take these aspects of teaching and learning into consideration.

Experience has shown that the art of learning can also be taught while teaching subject matter. People need to learn how to learn. V-TECS guides take into consideration how students learn and are an efficient way for instructors to assist them to learn.

V-TECS guides are centered around all three domains of learning: psychomotor, cognitive, and affective. The following is a brief explanation of each.

Psychomotor

Any manipulative skill such as tightening a nut, replacing a hubcap, sharpening a pencil, machining a key slot in a steel shaft, or replacing a SCR in a solid state control panel are examples of manipulative or psychomotor skills. Tasks such as these are identified in V-TECS catalogs. V-TECS catalogs also group tasks by duties and objectives. Each performance objective has a performance standard which must be met to prove student proficiency in the manipulative aspect of the task. The V-TECS catalog, however, does not include any suggestions on how to learn to do these tasks.

V-TECS guides are developed around psychomotor tasks which are worker oriented.

Cognitive

To perform psychomotor tasks, students must think. To tighten a nut they must know which way to turn it and when to stop turning it so that they won't strip the threads or shear the bolt off. If replacing a hubcap, there is a certain technique that may vary from one car to another. For example, start the hubcap by placing the cap in a tilted position and tapping it all the way around until it is properly seated. On a different model, it may be necessary to position the hubcap and snap it all at once. At any rate, students must think about what is being done. This is cognition or a mental activity. Cognition is what goes on in the mind about any job being done. V-TECS guides provide both the collateral knowledge and the impetus to apply cognition to psychomotor tasks.

Students gain cognition through both real and vicarious experiences. They may read, view tapes, memorize or practice a process or procedure until they are certain of it. To test their knowledge, students may be required to decide the proper procedure, method or sequence for performance. This is decision making or cognitive activity at its highest.

Cognition, then, is that process by which information is stored and used. That voice that warns one of potential dangers is cognition. Anything that goes on in the mind is cognition. Students may become the best workers in their job; but, if they fail to think a process through and apply their experience, they may become just one more statistic. It is cognition that tells them to lock and tag out the power supply to an electrical apparatus before starting to repair it. However, cognition does not apply only to safety. Good cognition or thinking can help employees do a job better and quicker. V-TECS guides provide for the cognitive aspects of learning.

Affective

Curriculum writers, supervisors, and instructors often fail to assist students in acquiring a positive attitude toward themselves, their jobs, their school, or their fellow students. V-TECS guides seek to provide assistance to the instructor in achieving this. It is difficult for the instructor to identify bits and pieces of desirable behavior for every unit and often harder yet to teach them. In this area, students might be judged as to how well they clean their work area, or whether they show up to do the job on time, or whether they must be told several times to do something. Potential employers are interested in student attitude because persons angry at themselves or uncertain of themselves are often poor workers.

A student's ability to succeed on the first job and every job thereafter depends largely on attitude. If, for example, students have the attitude of "let someone else do it," they could be in trouble. Students using V-TECS guides will have activities dealing with how to get along with other students, supervisors, or staff members in both large and small groups.

USE OF V-TECS GUIDE

The guide is designed to provide job-relevant tasks, performance objectives, performance guides, resources, learning activities, evaluation standards, and achievement testing in selected occupations.

A V-TECS guide is designed to be used with any teaching methods you may choose. If a lecture/demonstration method is best for you, you will find sufficient help to meet your needs. If you prefer to use discussions or other methods that require student participation, you will find ample help. Regardless of which method is successful for you, a V-TECS guide can save preparation time and offer innovative methods and procedures. For example, students may work either alone or in teams while in class and learn skills in direct relation to what is actually done on the job. This work also takes into consideration student attitudes, thinking skills, and mathematical reading skills.

The use of small groups in teaching can be helpful in two ways: (1) many students may feel inadequate due to their lack of background information in mechanical things; and (2) some students may feel that they are physically incompetent or lack the necessary background experiences. A successful program (course) can provide students with a sense of security by reinforcing positive attitudes while improving skill and knowledge of the subject. By allowing students to interact on a personal level, this task/learner-centered approach can achieve this. As students gain confidence and discover that they are an essential part of a team engaged in the learning-teaching process, their confidence increases. Too, the student in this setting can learn to work without direct supervision. In addition, use of the small-group method permits the instructor to vary instructional routines away from lecture or other full-class methods to activities for single students, pairs of students or any number so desired.

You will find suggestions for specific classroom activities. These activities are not meant to restrict you or your students, but only to suggest a variety of learning activities for each task statement. Please do not feel that you must take your students through all the activities.

South Carolina Objectives

The South Carolina writing team has added tasks which may be construed as enabling objectives. However, in order to be consistent, the team has referred to them as tasks.

These tasks/enabling objectives are needed for introductory information, theories and concepts, and background information necessary to understand machine shop operation. They are designated SC-1, SC-2, SC-3.

Nine tasks (P.O. 63, 68, 91, 92, 93, 94, 100, 101, and 175) were deleted by the South Carolina Curriculum Writing Team because of either obsolescence or post-secondary skill level.

SAFETY

DUTY: SAFETY

TASK Identify safety rules and regulations in the machine shop

PERFORMANCE OBJECTIVE SC-1

STANDARD: A score of 100% must be obtained on a safety rules and regulations test. Completed test must be kept on file for future reference.

SOURCE OF STANDARD: South Carolina Curriculum Writing Team

CONDITIONS FOR PERFORMANCE OF TASK:
- Safety films
- Charts
- Slogans
- Safety handbooks
- Safety equipment regulations required in respective states or localities
- Hand tools
- Power tools

PERFORMANCE GUIDE

N/A

LEARNING ACTIVITIES

1. Show and discuss safety film.
2. Distribute and discuss safety charts and slogans (either teacher-developed or commercially produced).
3. Explain use of safety equipment issued by school: safety glasses, goggles, aprons, gloves, etc.
4. Explain the importance of good housekeeping habits through keeping shop and work areas clean and free from oil and other hazardous materials.
5. Review first aid techniques and identify location of first aid kit.
6. Demonstrate safety practices for each piece of equipment in the shop.

RESOURCES

Johnson. **General Industrial Machine Shop**, pp. 19-24
"Basic Practices: Safety in Machine Shop" (3 films, 14 min. each, color)
Teacher-developed Safety Examination

EVALUATION

Written Questions

1. Name at least six safety rules and regulations to be followed in the machine shop.
2. Complete the safety test with 100% accuracy.

Answers

1. a. No horse play.
    b. Good housekeeping.
    c. Use safety glasses and equipment.
    d. Know how to use first aid to help another worker.
    e. Know proper use of fire extinguishers.
    f. Identify color standards for fire extinguishers (electrical and gas).
2. See attached sheet for Safety Examination answers.

SAFETY EXAMINATION

Name ______________________________ Date ____________________

DIRECTIONS: Read all questions first. On a separate sheet of paper, write the answers. Accuracy of 100% is required.

1. Name six safety precautions when using hand tools.
2. What is considered safe dress for a machinist?
3. When should safety glasses be worn in the shop?
4. How should clips be removed from the machine?
5. Why should a hammer be gripped close to the end of the handle.
6. What must be done before repairing a machine?
7. How should work be held in the drill press for drilling operations?
8. Name four safety rules used when using a grinder.
9. What is meant by good housekeeping in the shop?
10. What is the consequences of horseplaying in the shop?

SAFETY EXAMINATION ANSWERS

1. a. Always wear safety glasses.
   b. Use proper tools for work to be performed.
   c. Never abuse tools.
   d. Check tools for defects before starting to work.
   e. Keep hands away from sharp cutting edges, such as sheared edges, cutting with cold chisel, etc.
   f. Keep work area clean and uncluttered.

2. Clothes that do not hang loose, that could catch in rotating equipment.

3. At all times.

4. With a brush or hook, "never with bare hands."

5. To insure a firm grip so the hammer will not slip out of your hands.

6. Cut off all electrical power and lock out switches to make sure power is not turned on accidentally.

7. On a vise secured to table, never in the hand.

8. a. Check wheel for damage.
   b. Check rpm rating for safety.
   c. Wear safety glasses or face shield.
   d. Make sure work is secured in place.

9. Keeping shop clean and orderly, all objects off floor, no grease on floor and machine free of dirt and metal chips.

10. A person could be seriously injured by being pushed or running into moving equipment. Never allow horseplay in the shop.

MATH CALCULATIONS

DUTY: PERFORMING MATHEMATICAL CALCULATIONS

TASK: Calculate feeds and speeds

PERFORMANCE OBJECTIVE V-TECS 60

STANDARD: Speed must be within a tolerance of ± 5 RPM and feed within a tolerance of ± 0.001".

SOURCE OF STANDARD: Walker. **Machining Fundamentals**, pp. 151-253.

CONDITIONS FOR PERFORMANCE OF TASK:

Furnished with blueprint
Workpiece
Machinery specifications
Machinist's handbook
Milling cutter
Micrometer caliper
Steel rule
Milling machine

PERFORMANCE GUIDE

1. Review blueprint.
2. Measure workpiece.
3. Determine machining specifications
    a. Amount of stock to be removed.
    b. Number of cuts.
    c. Required finish.
    d. Workpiece material.
    e. Cutter material and size.
    f. Size of workpiece.
    g. Determine depth of cut.
4. Calculate speed of machine.
    a. Refer to machinist's handbook for formula.
    b. Round off to whole number.
5. Calculate feed of workpiece.
    a. Refer to machinist's handbook.
    b. Round off to nearest thousandth of an inch.
6. Verify calculations as within tolerance of 0.001".
    a. Accept calculations, or
    b. Reject calculations and repeat steps 1-5 until calculations are within specified tolerance.

LEARNING ACTIVITIES

1. Discuss the procedure to follow in preparation for calculating feeds and speeds, i.e., review blueprint, measure workpiece, determine specifications, etc.

2. Explain how to calculate speed of machine and feed of work piece.

3. Illustrate the formulas with examples.

4. Have students practice computing the formulas.

5. Explain how to verify calculations.

RESOURCES

Johnson. **General Industrial Machine Shop,** pp. 236-238.
Miller and Brueckman. **Machinist's Library — Basic Machine Shop,** pp. 236-242.

EVALUATION

Written Questions

Give the formulas for (a) calculating cutting speed and (b) calculating feed.

Answers

Calculating cutting speed:

$$CS = \frac{\pi \times DN}{12}$$

D = diameter of cutter in inches
N = RPM

Calculating feed:

$$F = R \times T \times RPM$$

F = feed rate in inches per minute
R = feed per revolutions of tooth per revolutions
T = number of teeth

DUTY: PERFORMING MATHEMATICAL CALCULATIONS

TASK: Convert fraction dimension to decimal dimension

PERFORMANCE OBJECTIVE V-TECS 67

STANDARD: The conversion from fraction dimension to decimal dimension must be to an accuracy of ± 0.001 inch.

SOURCE OF STANDARD: McCarthy and Smith. **Machine Tool Technology**, p. 47
Oberg, et. al. **Machinery's Handbook**, 21st ed., p. 2403

CONDITIONS FOR PERFORMANCE OF TASK:
Furnished with blueprint and machinist's handbook

PERFORMANCE GUIDE

1. Note fractional part of dimension.
2. Divide numerator of fraction by denominator of fraction.
3. Round answer off to nearest .001".
4. Verify answer by placing number over 1000 and reducing.
5. Verify answer with decimal equivalent chart.

LEARNING ACTIVITIES

1. Explain how to determine fractional part of dimensions on blueprint.
2. Explain how to convert a common fraction to decimal fraction.
3. Demonstrate the procedure used in verifying the answer.
4. Have students practice converting common fractions to decimal fractions and converting decimal to common fractions.
5. Provide students with blueprints with common fractions to convert.

RESOURCES

LeGrand. **The New American Machinist's Handbook**, pp. 44.3-44.6.

EVALUATION

Written Questions

Convert the following common fractions to decimal fractions to an accuracy of ± 0.001" using conversion chart as guide.

1. $\frac{11}{16}$ =
2. $\frac{1}{8}$ =
3. $\frac{19}{32}$ =
4. $\frac{5}{16}$ =
5. $\frac{3}{32}$ =

Answers

1. .6875
2. .125
3. .5937
4. .3125
5. .0937

DUTY: PERFORMING MATHEMATICAL CALCULATIONS

TASK: Calculate amount of stock required in machine work

PERFORMANCE OBJECTIVE V-TECS 57

STANDARD: Maximum use of scrap stock must be maintained. All data on Bill of Materials (stock required to perform the job specified on the blueprint) must be entered without error.

SOURCE OF STANDARD: McCarthy and Smith. **Machine Tool Technology**, p. 49

CONDITIONS FOR PERFORMANCE OF TASK:
Furnished with blueprint and inventory of stock (scrap pile and metal rack)
Micrometer calipers
Telescoping gages
Steel rule
Steel tape

PERFORMANCE GUIDE

1. Study blueprint.
    a. Check finished stock size.
    b. Check material required.
2. Check scrap stock.
    a. Select and measure available stock.
    b. Consider work-holding device.
    c. Consider machining operation.
3. Complete attached Bill of Materials.

LEARNING ACTIVITIES

1. Review blueprint thoroughly.
2. Explain how to complete a Bill of Materials, using a sample form.
3. Have students determine and select materials required for a specified job. Finished stock size should be used if possible.
4. Check scrap stock to determine feasibility of machining to size.
5. Determine time involved using scrap material compared with new material.
6. Have students make a list of material to be used and complete a Bill of Materials.

RESOURCES

Johnson. **General Industrial Machine Shop**, p. 25.
Student Information Sheet

EVALUATION

Written Questions

From the attached blueprint and the following inventory of stock (scrap pile and metal rack), complete a Bill of Materials without error.

Bill of Materials: Cold rolled steel
1 piece $1\frac{1}{4}$" x $\frac{5}{8}$" flat steel $6\frac{1}{4}$" long
NOTE: Stock has to be the size stated above to allow for machining

PERFORMANCE OBJECTIVE V-TECS 57 continued

Answer
Instructor must review the completed Bill of Materials for proper placement of information.

ATTACHMENT (P.O. 57)

BILL OF MATERIALS

JOB ______________________ JOB ORDERED BY ______________________

(DATE)

WORKER ______________________ JOB APPROVED BY ______________________

(DATE)

PART DESCRIPTION AND IDENTIFICATION NUMBER	NUMBER NEEDED	KIND OF MATERIAL	MATERIAL	
			SIZE	SHAPE

ATTACHMENT (P.O. 57)

CHECKLIST: STOCK UTILIZATION

BILL OF MATERIALS IDENTIFICATION NUMBER	MATERIAL AVAILABILITY				MATERIAL UTILIZATION*			
	SCRAP PILE		METAL RACK		SCRAP WHEN AVAILABLE OVER METAL RACK		SIZING TO REDUCE LABOR	
	YES	NO	YES	NO	YES	NO	YES	NO

*Standards: Use scrap when available over new metal rack supply and correct size selection to reduce labor.

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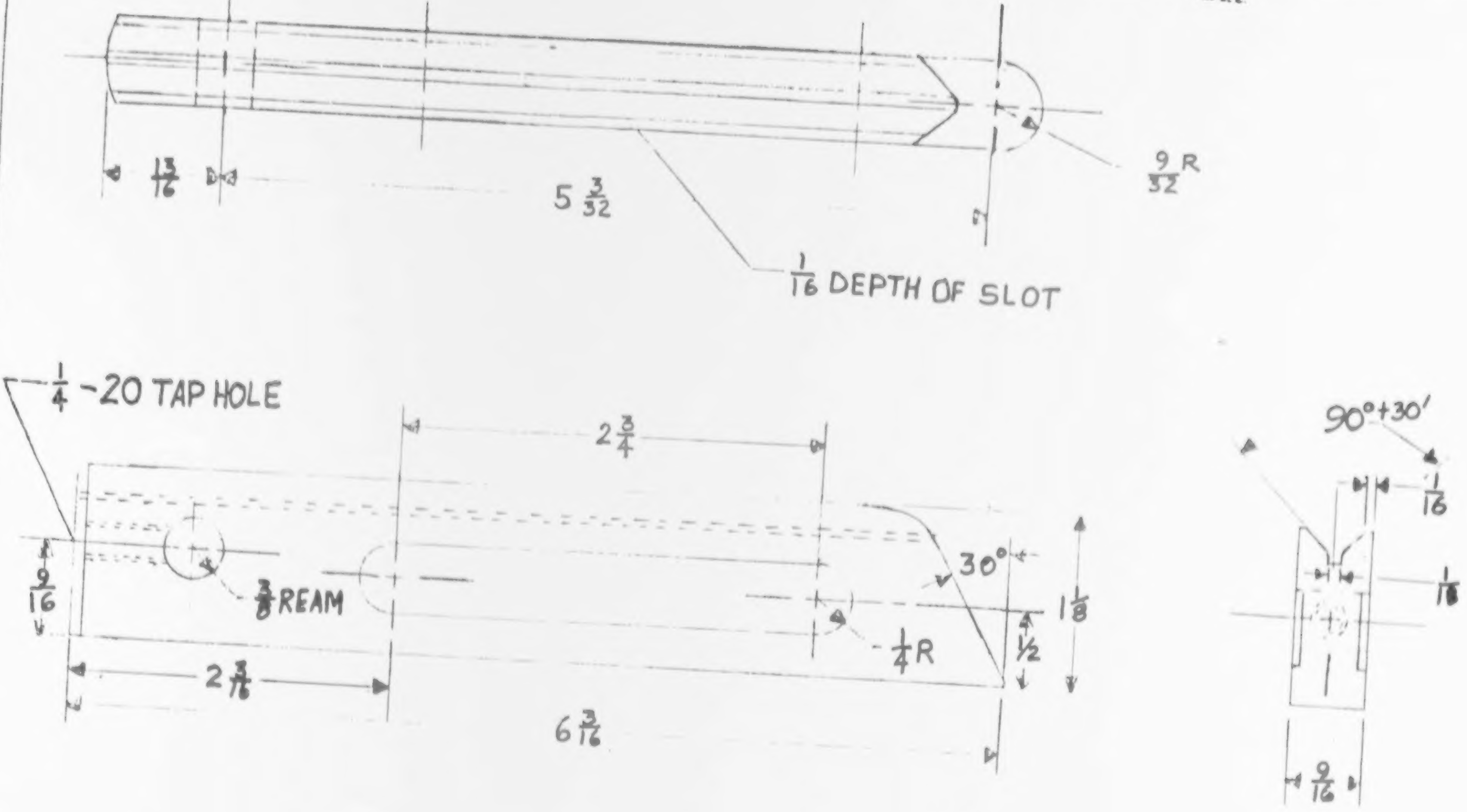

13/16
5 3/32
9/32 R
1/16 DEPTH OF SLOT
1/4 -20 TAP HOLE
2 3/4
9/16
3/8 REAM
30°
1/4 R
1 1/8
1/2
2 3/16
6 3/16
90°±30′
1/16
1/16
9/16

UNLESS OTHERWISE SPECIFIED:
TRUE CENTERS WITHIN ±.003 OF CENTER LINE CONCENTRICITY ±.001
DIMENSIONAL TOLERANCE: FRACTION ± 1/64; DECIMAL ±.003; ANGULAR 2°

MATERIAL
C.R.S
HEAT TREAT

BASE
BORING BAR HOLDER
NO. REQD 1
SCALE: FULL
SHEET 1 OF 1
DWG NO. 1

DUTY: PERFORMING MATHEMATICAL CALCULATIONS

TASK: Calculate tapers for machine set-up.

PERFORMANCE OBJECTIVE V-TECS 65

STANDARD: The dimensions must be within a tolerance of ± 0.001 inch on decimal dimensions, ± 1/64 inch on fraction dimensions, and ± 5 minutes on angular dimensions.

SOURCE OF STANDARD: Oberg, et. al. **Machinery's Handbook**, pp. 389-391.
Olivo. **Fundamentals of Machine Technology**, p. 19.

CONDITIONS FOR PERFORMANCE OF TASK:
Furnished with blueprint
Workpiece
Machinist's handbook

PERFORMANCE GUIDE

1. Study blueprint
2. Determine dimensions defining taper
3. Calculate taper per inch using formula
   a. Small diameter, large diameter, and length given, use formula:

   $$T = \frac{(D-d)}{L}$$

   T = taper per inch
   D = large diameter in inches
   d = small diameter in inches
   L = length of taper in inches

   b. To obtain taper per foot multiply (T) by 12

   c. When small diameter, large diameter, length of taper are given but overall length is longer than taper use the formula:

   $$\text{tpf} = \frac{\text{large diameter} - \text{small diameter} \times 12}{\text{length of taper (in.)}}$$

   *d. To calculate tailstock offset use formula:

   $$\text{Offset} = \frac{\text{tpf} \times \text{total length (in.)}}{24}$$

4. Verify calculations with machinist's handbook.
   a. Accept calculation, or
   b. Reject calculations and/or take corrective action.

RESOURCES

LeGrand. **The New American Machinist's Handbook**, pp. 35-2.

*NOTE: South Carolina Writing Team does not recommend teaching tailstock offset.

EVALUATION

Written Questions

1. To compute tapers for machine set up, give formulas for taper per inch and taper per foot.
2. What is the formula for offsetting tailstock to give desired taper?

Answer

1. Taper per inch: $T = \frac{(D-d)}{L}$

   Taper per foot: $tpf = \frac{\text{large diameter - small diameter} \times 12}{\text{length of taper (in.)}}$

2. Offset tailstock: $\text{Offset} = \frac{tpf \times \text{total length (in.)}}{24}$

DUTY: **PERFORMING MATHEMATICAL CALCULATIONS**

TASK: Calculate gear blank specifications

PERFORMANCE OBJECTIVE V-TECS 62

STANDARD: Calculations must be to an accuracy of $^{+}$ 0.001 inch.

SOURCE OF STANDARD: Kibbe, et. al. **Machine Tool Practices**, p. 668
Oberg, et. al. **Machinery's Handbook**, p. 724.

CONDITIONS FOR PERFORMANCE OF TASK:
Given blueprint
Workpiece
Reference material
Gear blank
Gear tables

PERFORMANCE GUIDE

1. Study blueprint.
2. Determine diametrial pitch and number of teeth.
3. Calculate outside diameter of gear blank.
   a. Use formula: $$O\,D = \frac{N + 2}{P}$$

   O D = outside diameter
   N = number of teeth
   P = diametrial pitch

   b. Check answer with table or handbook
4. Calculate depth of tooth.
   a. Use formula: $$d = \frac{2.157}{P}$$

   d = depth of tooth
   p = diametrial pitch

   b. Check answer with table, handbook or cutter
5. Calculate tooth thickness.
   a. Use formula: $$t = \frac{1.5108}{P}$$

   t = tooth thickness
   P = diametrial pitch

   b. Check table or handbook
6. Calculate addendum.
   a. Use formula: $$a = \frac{1.0}{P}$$

   a = addendum
   p = diametrial pitch

7. Calculate chordal addendum
   a. Use formula: $ca = a + \frac{t^2}{4D}$

      ca = chordal addendum
      a = addendum
      t = tooth thickness
      D = outside diameter
8. Calculate chordal thickness
   a. Use formula: $ct = D \sin \frac{(90)}{N}$

      ct = chordal thickness
      D = outside diameter
      N = number of teeth
   b. Verify machinery handbook or tables for answers
9. Recommend calculations are within or without specified accuracy
   a. Approve calculations, or
   b. Repeat calculations until they are within required tolerance

RESOURCES

Le Grand. **The New American Machinist's Handbook**, pp. 4.1-4.52.

EVALUATION

Written Questions

Give the formulas for cutting a gear from a blank:

a. outside diameter of gear blank
b. depth of tooth
c. tooth thickness
d. calculate addendum
e. chordal addendum
f. chordal thickness

Answers

a. outside diameter of gear blank
   Use formula: $O\,D = \frac{N + 2}{P}$

   O D = outside diameter
   N = number of teeth
   P = diametrial pitch

b. depth of tooth
   Use formula: $d = \frac{2.157}{P}$

   d = depth of tooth
   p = diametrial pitch

PERFORMANCE OBJECTIVE V-TECS 62 Continued

c. tooth thickness
Use formula: $t = \frac{1.5108}{p}$

t = tooth thickness
p = diametrial pitch

d. addendum
Use formula: $a = \frac{1.0}{p}$

a = addendum
p = diametrial pitch

e. chordal addendum
Use formula: $ca = a + \frac{t^2}{4D}$

ca = chordal addendum
a = addendum
t = tooth thickness
D = outside diameter

f. chordal thickness
Use formula: $ct = D \sin \frac{(90)}{N}$

ct = chordal thickness
D = outside diameter
N = number of teeth

DUTY: PERFORMING MATHEMATICAL CALCULATIONS

TASK: Calculate tap drill size with formula

PERFORMANCE OBJECTIVE V-TECS 64

STANDARD: The calculation must match by 100% tap drill chart for 80% thread depth.

SOURCE OF STANDARD: Kibbe, et. al. **Machine Tool Practices**, p. 74
Krar, et. al. **Technology of Machine Tools**, p. 477

CONDITIONS FOR PERFORMANCE OF TASK:
Furnished with blueprint
Workpiece and reference material

PERFORMANCE GUIDE

1. Check blueprint for threaded hole size.
2. Calculate tap drill size
   - a. Use formula:

     $$\text{Hole size} = \frac{.0129 \times \%\ \text{of thread}}{\text{Number of threads per inch}}$$

   - b. Round off answer to nearest 1/1000th (0.001) of an inch.
3. Select tap drill
   - a. Check letter, number and fraction charts for decimal equivalents
   - b. Select drill nearest to calculations
4. Match drill size with drill size on tap drill chart
   - a. Accept calculations, or
   - b. Reject calculations and repeat steps 1-4 until calculations match chart.

LEARNING ACTIVITIES

1. Study blueprint.
2. Review formula for tap drill size from Machinist's Handbook or Handbook of Taps and Dies.
3. Determine correct size drill for tapping hole. Letter drills, number drills or fraction drill for desired hole size.
4. Check tap drill chart against formula for accuracy.
5. Identify type of metal to be tapped, hard or soft consistency.

RESOURCES

LeGrand. **The New American Machinist's Handbook**, pp. 11.2-11.20.
Union Carbide Corp. **Handbook of Taps and Dies.** (Other pocket guides may be ordered from other tool companies)

EVALUATION

Written Questions

For a hole 3/4" in diameter, ten threads per inch, and 80% thread depth, calculate tap drill size using the formula:

$$\text{Hole size} = \frac{.0129 \times \%\ \text{of thread}}{\text{Number of threads per inch}}$$

Answer

Tap drill size .750 = $\frac{.0129 \times 80}{10}$

DUTY: PERFORMING MATHEMATICAL CALCULATIONS

TASK: Calculate conversions of revolutions per minute (RPM) of grinding wheel to surface per minute (SFPM).

PERFORMANCE OBJECTIVE V-TECS 58

STANDARD: Round off answer to the decimal point. Answer must be within five SFPM and maximum speed not exceed handbook specifications.

CONDITIONS FOR PERFORMANCE OF TASK:
Furnished with reference material
Grinding wheel specifications
Grinding machine specifications
Reference or formula
Machinist's handbook

PERFORMANCE GUIDE

1. Check grinding wheel diameter.
2. Check grinding wheel for maximum speed noted.
3. Check speed of grinder.
4. Calculate surface feet per minute (SFPM) using the formula:
   sfpm = rpm x D/12 x π
   D = Diameter of wheel in inches
   $\pi = 3.14$
5. Check maximum speed in machinist's handbook to insure calculated speed is within handbook specifications.

LEARNING ACTIVITIES

1. Define surface feet per minute (SFPM).
2. Explain how to check grinding wheel diameter and speed of grinder.
3. Demonstrate how to compute the formula for SFPM.
4. Show students how to check wheel diameter for cracks and maximum speed of wheel.
5. Review maximum speeds in handbook to make sure the calculated speed is within specifications.
6. Have students practice using the formula with examples.

RESOURCES

LeGrand. **The New American Machinist's Handbook**, pp. 5-2 - 5-34
Handout by Norton Grinding Wheel Co.

EVALUATION

Written Question

What is the surface speed per minute of a wheel 8" in diameter turning 5000 RPM?

Answer

$$\frac{3.1416 \times 8'' \times 5000}{12} = 10{,}486.66$$

DUTY: PERFORMING MATHEMATICAL CALCULATIONS

TASK: Calculate for angular and simple indexing

PERFORMANCE OBJECTIVE V-TECS 61

STANDARD: Simple indexing dimensions must be without error and angular indexing dimensions must be within a tolerance of + 5 minutes.

CONDITIONS FOR PERFORMANCE OF TASK:

Furnished with blueprint
Reference material
Workpiece
Indexing head
Index plates
Machinist's handbook

PERFORMANCE GUIDE

1. Study blueprint.
2. Note index head and index plates available.
3. Calculate simple indexing movement
   a. Refer to machinist's handbook
   b. Use formula to obtain simple indexing movement

      $\frac{40}{\text{No. of divisions}} = \text{no. of turns}$

   c. For partial turns (fractional) reduce or increase fraction until the denominator equals the number of holes in an index plate

      Example:

      $\frac{3}{7} = \frac{3}{7} \times \frac{3}{3} = \frac{9}{21}$ (index plate no.)

   d. Use table to check calculations
   e. Simple indexing spacing must be exact.
4. Calculate angular indexing dimension
   a. One full turn on index head equals 9°
   b. Calculate number of full turns for each 9° required
   c. Select index plate with hole circle divisible by 9 for degrees less than 9
   d. Divide hole circle by 9 to find number of holes for each degree
   e. For angular indexing minutes, convert degrees to minutes and use formula:

      $\frac{\text{Minutes required}}{540}$

5. Verify calculations with tables in machinist's handbook.

LEARNING ACTIVITIES

1. Review reading assignment.
2. Define angular and simple indexing.
3. Explain the formula and how it is computed.
4. Demonstrate how to convert degrees to minutes.
5. Explain how to verify calculations.
6. Have students practice working formulas from examples provided by the teacher.

RESOURCES

Johnson. **General Industrial Machine Shop**, pp. 464-467.

EVALUATION

Written Questions

1. What are the two most common dividing heads in use today?
2. Explain simple indexing.

Answers

1. The 40-1 ratio and the 5-1 ratio.
2. A worm wheel attached to the spindle of the index head and moved through a worm. The worm is keyed to a shaft to which a crank is attached. One complete revolution of the crank causes any one tooth on the worm gear to make a complete revolution. Forty turns of the crank are required to turn the spindle one full revolution.

DUTY: **PERFORMING MATHEMATICAL CALCUALTIONS**

TASK: Calculate tolerances or allowances

PERFORMANCE OBJECTIVE 66

STANDARD: Calculations for a specific job must be to a bilateral tolerance of ± 0.001".

SOURCE OF STANDARD: Oberg, et. al. **Machinery's Handbook**, p. 1528

CONDITIONS FOR PERFORMANCE OF TASK:
Furnished with workpiece
Blueprint
References
Machinist's handbook

PERFORMANCE GUIDE

1. Study blueprint
   a. Note fit required
   b. Tolerance of mating part
   c. Tolerance in handbook for desired fit
   d. Note nominal diameter
2. Calculate bilateral tolerance with formula:
   a. Maximum size of mating part plus maximum tolerance (for desired fit) of mating part, equals upper limit of workpiece dimension
   b. Minimum size of mating part minus minimum tolerance (for desired fit) of mating part equals lower limit of workpiece dimensions
   c. Upper limit minus lower limit = total allowance of workpiece
   d. $\frac{\text{Total allowance of workpiece}}{2}$ = bilateral tolerance
3. Repeat steps 1-2 and verify claculations
   a. Accept calculations
   b. Reject calculations and/or take corrective action

LEARNING ACTIVITIES

1. Check blueprint.
2. Explain meaning of maximum and minimum tolerances.
3. Check machinist handbook for allowable tolerances for specific problems.
4. Have students figure the correct fit by using formula on bilateral tolerance.
5. Discuss problem and review formula for accuracy.

RESOURCES

Lascoe, et. al. **Machine Shop Operation and Setups**, p. 20
Repp and McCathy. **Machine Tool Technology**, pp. 22-23

EVALUATION

Written Questions

1. Define the meaning of the term tolerance.
2. Define the meaning of the term allowance.

Answer

1. Tolerance is the total permissable variation of a size. It is the difference between the maximum and minimum limits of size.
2. Allowance is an intentional difference between the maximum material size limits of mating parts. it is the minimum clearance (positive allowance) or maximum interference (negative allowance) between mating parts.

DUTY: PERFORMING MATHEMATICAL CALCULATIONS

TASK: Calculate depths and widths of slots and grooves on special setups

PERFORMANCE OBJECTIVE V-TECS 59

STANDARD: A tolerance of ± 0.001" must be obtained in calculations.

CONDITIONS FOR PERFORMANCE OF TASK:
- Furnished with blueprint
- References
- Workpiece
- Micrometer
- Vernier
- Caliper
- Depth micrometer

PERFORMANCE GUIDE

1. Study blueprint.
2. Determine dimensions needed for machining workpiece.
3. Check machinist's handbook for table or formula.
4. Calculate required dimensions and round off answer to nearest 0.001".
5. Repeat steps 2-4 and check answers.
6. If answers do not check, repeat steps 2-4 until answers are within 0.001".

LEARNING ACTIVITIES

1. Compare workpiece with blueprint.
2. Explain the simplest steps to check for measurement.
3. Determine if formulas in handbook are needed.
4. Discuss how to determine dimensions needed for machining workpiece.
5. Demonstrate how to calculate depths and widths of slots and grooves on a special set up.
6. Have students practice calculating depths and widths. Verify answers for accuracy.

RESOURCES

Johnson. **General Industrial Machine Shop**, pp. 406-459.

EVALUATION

Written Questions

1. What are the two most commonly used instruments used in measuring slots and grooves?
2. Where is the starting point of the cut when cutting a splined shaft?

Answers

1. Depth micrometer
   Vernier Caliper
2. Tap dead Center

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DESIGN & PLAN MACHINE WORK

DUTY: **DESIGNING AND PLANNING MACHINE WORK**

TASK: Interpret and sketch multi-view drawings

PERFORMANCE OBJECTIVE SC-2

STANDARD: The multi-view drawing of a machined object must show at least two or more views (end view, side view, top view, etc.) with 90% accuracy.

SOURCE OF STANDARD: South Carolina Curriculum Writing Team

CONDITIONS FOR PERFORMANCE OF TASK:
Given sketches and blueprints
Measuring instruments
Pad and pencil

PERFORMANCE GUIDE

N/A

LEARNING ACTIVITIES

1. Review blueprint for all views.
2. Check the drawing for proper fits and accuracy and for missing dimensions.
3. Visualize the finished product by combining views to show the finished product.
4. Explain how the different views are drawn.
5. Demonstrate the procedure in sketching a multi-view drawing.

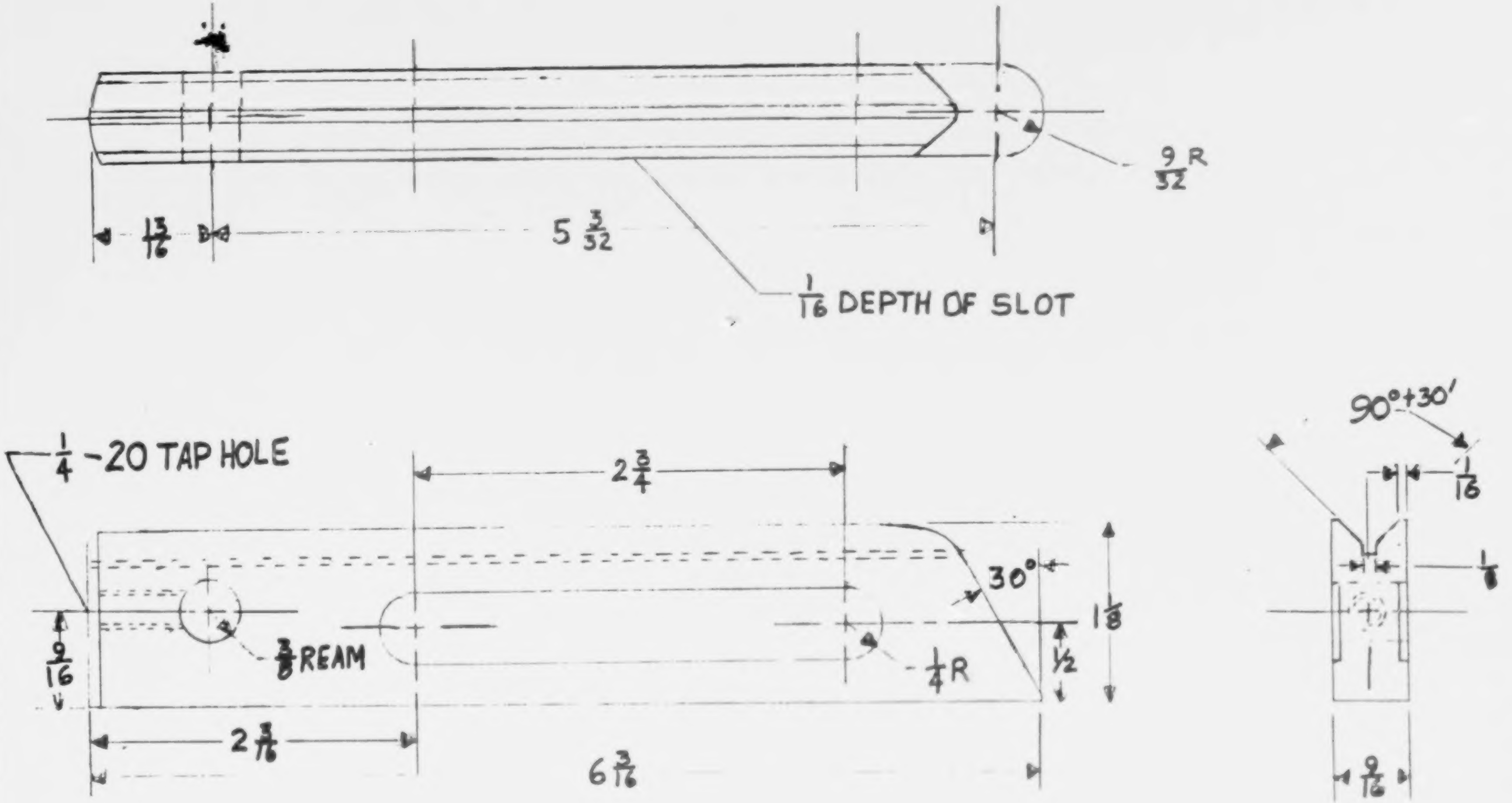
RESOURCES

Johnson. **General Industrial Machine Shop**, pp. 38-48.

EVALUATION

Written Question
Draw a multi-view sketch of a machine object showing the three-dimensional views of the object. (Use attached sheet)

Answer
(Instructor must check for accuracy.)


9/32 R
13/16
5 3/32
1/16 DEPTH OF SLOT
1/4 -20 TAP HOLE
2 3/4
30°
1 1/8
1/2
1/4 R
3/8 REAM
9/16
2 3/16
6 3/16
90°±30'
1/16
1/8
9/16

UNLESS OTHERWISE SPECIFIED:
TRUE CENTERS WITHIN ±.003 OF CENTER LINE CONCENTRICITY 1.001
DIMENSIONAL TOLERANCE: FRACTION $\pm\frac{1}{64}$; DECIMAL ±.003; ANGULAR 2°

MATERIAL
C.R.5
HEAT TREAT

BASE
BORING BAR HOLDER
NO. REQD 1
SCALE: FULL
SHEET 1 OF 1
DWG NO. 1

BEST COPY AVAILABLE

DUTY: **DESIGNING AND PLANNING MACHINE WORK**

TASK: Make sketches of work to be machined

PERFORMANCE OBJECTIVE V-TECS 1

STANDARD: Sketch must show all views and dimensions required with job specifications.

SOURCE OF STANDARD: Giesecke, et. al. **Technical Drawing**, pp. 8, 125

CONDITIONS FOR PERFORMANCE OF TASK:

- Machinist's handbook
- Micrometer caliper
- Steel rule
- Inside micrometer
- Screw pitch gage
- Workpiece with missing part

PERFORMANCE GUIDE

1. Study workpiece.
2. Sketch view(s) of missing part.
3. Dimension sketch
    a. Measure workpiece.
    b. Consult machinist's handbook for threads, fits, tapers and tolerances.
    c. Calculate dimensions needed for machining part.
4. Check sketch dimensions against machining requirements.
5. Assure that views and dimensions meet job specifications.

LEARNING ACTIVITIES

1. Explain the use of blueprints in the machine shop.
2. Using a blueprint sketch, locate the stated dimensions and the missing dimensions with the use of a formula.
3. Explain how the missing dimensions are computed.
4. Have students practice computing the formula for missing dimensions on two blueprints developed by teacher.
5. Explain the meaning of footnotes or written instructions and the importance of verbal instructions and footnotes.
6. Test the students on their ability to follow instructions both verbal and written.
7. Identify the drafting symbols used in blueprint reading and their meanings.
8. Review symbols used in machine drawings and symbols for finished and drilled surfaces.

RESOURCES

LeGrand. **The New American Machinist's Handbook**, pp. 39-2 -- 39-15.
Johnson. **General Industrial Machine Shop**, pp. 38-48.
Berg. **Mechanical Drawing**, pp. 183-238.

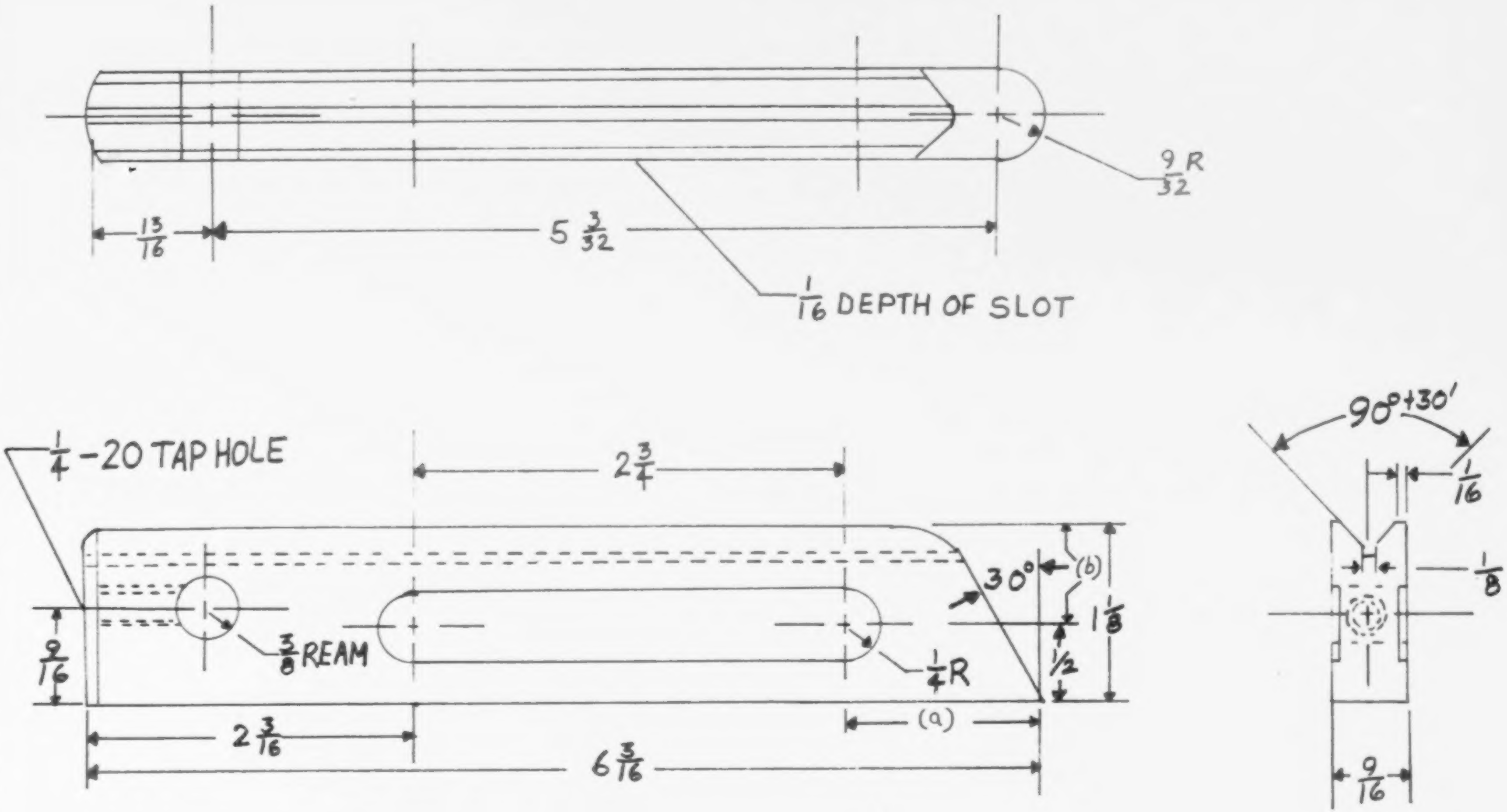
EVALUATION

Written Questions

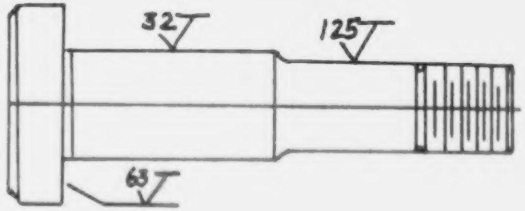
1. On the attached blueprint sketch
    a. compute the missing dimensions and
    b. explain the meaning and purpose of the footnotes.
2. Why are written and verbal instructions important when working from sketches or blueprints?
3. Give the symbols for external and internal threads and for finished surfaces.

Answers

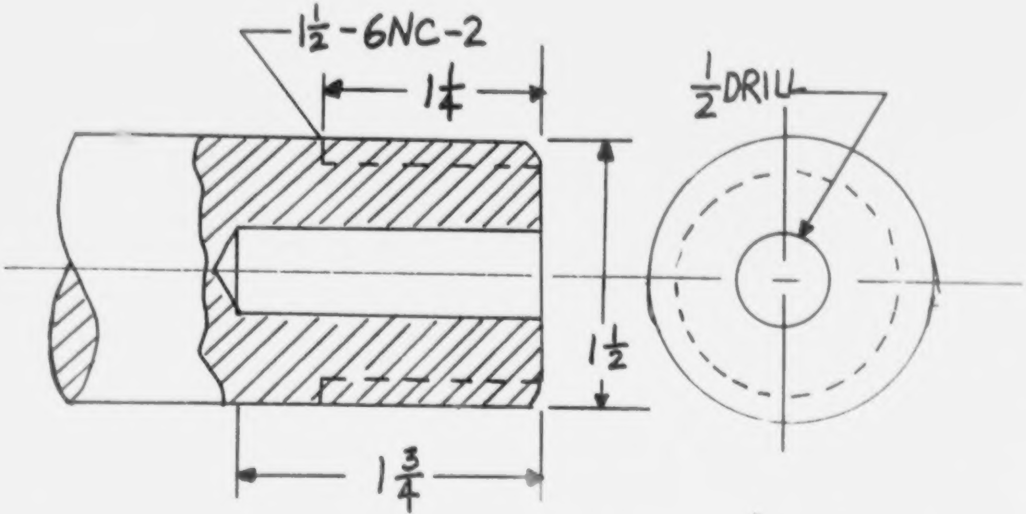
1. a. Missing dimension is a. 2 1/4 and b. 5/8
    b. Blueprint footnotes identify tolerances, scale of drawing, type of metal and any other related performances on the blueprint. On the given blueprint, the following are defined:
    MATERIAL -- Type of metal
    HEAT TREATMENT -- Hardening or annealing
    BASE -- Part of workpiece being fabricated
    BORING BAR HOLDER -- Part of workpiece being fabricated
    NO. REQUIRED -- Number of pieces required
    SCALE -- Full size of workpiece
    DESCRIPTION -- Tolerances permitted
2. To specify dimensions and tolerances so that the student or worker has a clear understanding of the procedures.


9/32 R
13/16
5 3/32
1/16 DEPTH OF SLOT
1/4-20 TAP HOLE
2 3/4
3/8 REAM
1/4 R
30°
(b)
1 1/8
1/2
9/16
(a)
2 3/16
6 3/16
90°±30'
1/16
1/8
9/16

	MATERIAL		BASE
UNLESS OTHERWISE SPECIFIED: TRUE CENTERS WITHIN + .003 OF CENTER LINE CONCENTRICITY 1.001 DIMENSIONAL TOLERANCE: FRACTION ± 1/64;DECIMAL ± .003;ANGULAR 2°	C.R.5		BORING BAR HOLDER
	HEAT TREAT	NO. REQD 1	SCALE:FULL — SHEET 1 OF 1
			DWG NO. 1

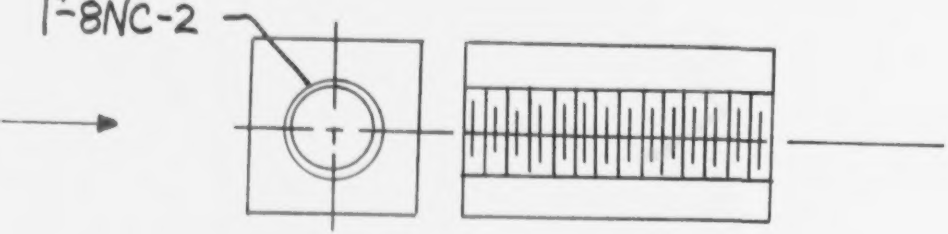


FINISHED SYMBOLS


1½-6NC-2
1¼
1½
1¾
½ DRILL

EXTERNAL

INTERNAL



DUTY: DESIGNING AND PLANNING MACHINE WORK

TASK: Apply company standards

PERFORMANCE OBJECTIVE SC-3

STANDARD: The time limitations, shipping, and receiving information must be identified in at least two companies' standards.

SOURCE OF STANDARD: South CArolina Curriculum Writing Team

CONDITIONS FOR PERFORMANCE OF TASK:
Given a sample copy of a company's policy for maximum and minimum conditions allowable
A discussion on importance of time limitations
Shipping and receiving

PERFORMANCE GUIDE

N/A

LEARNING ACTIVITIES

1. Have students read a sample set of company standards and discuss the important factors.
2. Explain and check off permissable tolerances and dimensions.
3. Identify types of finish and job specifications.
4. Emphasize the importance of time involved for work done and the ability to meet deadlines and the consequences if deadline is not met.
5. Discuss how raw materials and finished products are delivered.
6. Describe and discuss shipping and receiving methods for several companies.

NOTE: Instructor may have to write a sample set of company standards, i.e., "This standard is to be considered for all safety considerations. Tolerances: fractions ± 1/64, decimals ± .001, angles ± 5°. Please forward expected shipping date and method of delivery."

RESOURCES

A sample set of company standards.

EVALUATION

Written Question

Name at least three steps taken in the application of company standards in designing and planning machine work.

Answers

a. Method of shipping and receiving
b. Time limitations
c. Dimensions and tolerances

PRECISION MEASUREMENT

DUTY: PERFORMING PRECISION MEASUREMENT

TASK: Care for precision instruments

PERFORMANCE OBJECTIVE V-TECS 2

STANDARD: Precision instruments must be free of rust and grease and stored in designated case/cabinet.

SOURCE OF STANDARD: Heineman and Genevro. **Machine Tools Processes and Applications,** pp. 56-66.

CONDITIONS FOR PERFORMANCE OF TASK:

- Furnished with precision instruments
  - Micrometer
  - Vernier calipers
  - Bevel protractors
  - Dial indicators
  - Vernier height gages
  - Vernier depth gages
- Storage cases
- Storage cabinets
- Cleaning solution
- Rags
- Standards

PERFORMANCE GUIDE

1. Remove all grease from instrument.
   a. Apply cleaning solution.
   b. Wipe surfaces clean and dry.
2. Remove all rust from instruments surfaces.
   a. Apply rust remover.
   b. Wipe surfaces clean and dry.
   c. Burnish surfaces with crocus cloth.
3. Coat lightly all bright surfaces with lubricating oil.
4. Insure instrument is aligned.
   a. Check instrument with standard.
   b. Adjust instrument to standard or zero reading.
5. Store instrument.
   a. Place in designated instrument case and/or
   b. Place in designated storage cabinet.
   c. Place in humidity controlled area.

LEARNING ACTIVITIES

1. Emphasize importance of caring for tools.
2. Demonstrate how to clean tools.
3. Have students clean and oil measuring tools.
4. Have students observe each other as they clean and oil tools.
5. Discuss reading and study assignments (including all pictures and figures) any or all of the books listed on the next page.

PERFORMANCE OBJECTIVE V-TECS 2 Continued

RESOURCES

Krar, et. al. **Technology of Machine Tools**, pp. 4, 9, 27.
Lascoe, et. al. **Machine Shop Operations and Set-ups**, p. 15.
Walker. **Machining Fundamentals**, pp. 31, 38, 45.

EVALUATION

Written Question

Name at least five steps in caring for precision instruments.

Answers

a. Clean with solvent.
b. Polish with crocus cloth.
c. Check for blemishes, scratches and misalignment.
d. Oil with light machine oil (not motor oil).
e. Store in cases, tool boxes, etc.

DUTY: PERFORMING PRECISION MEASUREMENT

TASK: Measure work with tape measure

PERFORMANCE OBJECTIVE V-TECS 24

STANDARD: The workpiece must be within a tolerance of ± 1/64".

SOURCE OF STANDARD: Heineman and Genevro. **Machine Tools Processes and Applications,** p. 50.

CONDITIONS FOR PERFORMANCE OF TASK:
Furnished with workpiece
Blueprint
Tape rule

PERFORMANCE GUIDE

1. Clean and deburr workpiece.
2. Measure workpiece
   a. Inside measurements add 2" for rule case.
   b. Butt hook against workpiece on inside measurements.
   c. Hook rule over edge of workpiece on outside measurements.
3. Verify workpiece dimension as within or without specified tolerance.
   a. Approve workpiece, or
   b. Reject workpiece.

LEARNING ACTIVITIES

1. Explain the proper use of the tape measure.
2. Read and explain the instructions on job sheet and blueprint.
3. Demonstrate the use of the tape measure.
4. Demonstrate by performing measurements on workpiece.
5. Compare measurements with specifications on blueprint.

RESOURCES

Refer to manufacturer's bulletin or instructions on package.
Lascoe, et. al. **Machine Shop Operations and Setup,** 3rd edition, p. 11.

EVALUATION

Written Question
Tape measures are considered ______________ measuring instruments.

Answer
Non-precision

DUTY: PERFORMING PRECISION MEASUREMENT

TASK: Measure work with 6" pocket rule

PERFORMANCE OBJECTIVE V-TECS 22

STANDARD: Measurement must be within a tolerance of ± 1/64".

SOURCE OF STANDARD: Walker. **Machining Fundamentals,** p. 30.
Kibbe, et. al. **Machine Tool Practices,** p. 118

CONDITIONS FOR PERFORMANCE OF TASK:
Furnished with workpiece
Blueprint
Pocket rule

PERFORMANCE GUIDE

1. Clean and deburr workpiece.
2. Check blueprint for required dimension.
3. Measure workpiece.
   a. Select reference point.
   b. Use 1/64" graduated scale.
   c. Stand rule on edge to avoid parallax error.
   d. Avoid using end of rule because of possible wear on rule.
   e. Use one inch mark as reference.
   f. Allow for this one inch in calculating measurement.
   g. If measuring an end diameter, move rule until largest reading is obtained.
   h. Repeat measuring until two or more measurements are within tolerance.

LEARNING ACTIVITIES

1. Give instructions on how 6" rule is graduated.
2. Demonstrate proper use of rule.
3. Discuss reading assignment and study pictures and figures in any or all of the books listed below.
4. Perform measurements on workpiece.
5. Compare measurements with specifications on blueprint.

RESOURCES

Anderson and Tatro. **Shop Theory,** 5th edition, pp. 56-58.

Lascoe, et. al. **Machine Shop Operations and Setups** (3rd edition, pp. 9-12) (4th edition, pp. 9-15).

EVALUATION

Written Questions

1. Define parallax error.
2. Why is it good practice not to measure to end of rules?

Answers

1. Error in measurement due to observing rule graduations at an angle other than 90° or 0°.
2. Rules become worn or burred at the ends.

DUTY: **PERFORMING PRECISION MEASUREMENT**

TASK: Measure work with slide caliper rule

PERFORMANCE OBJECTIVE V-TECS 21

STANDARD: The workpiece must be measured to within a tolerance of ± 1/64".

SOURCE OF STANDARD: Heineman and Genevro. **Machine Tools Processes and and Applications,** p. 50.

CONDITIONS FOR PERFORMANCE OF TASK:
Furnished with workpiece
Blueprint
Slide caliper rule
Micrometer

PERFORMANCE GUIDE

1. Clean and deburr workpiece.
2. Check slide caliper rule with micrometer.
3. Measure workpiece.
    a. Release lock first.
    b. Slide movable jaw against workpiece.
    c. Lock movable jaw.
    d. Note "inside" or "outside" measurement tolerance of + 1/64".
4. Verify workpiece as within or without.
    a. Accept workpiece, or
    b. Reject workpiece

LEARNING ACTIVITIES

1. Instruct students on proper use of slide caliper rule and nomenclature.
2. Discuss the instructions on job sheet and blueprint.
3. Demonstrate how to measure with slide caliper rule.
4. Have students observe and assist other students.
5. Discuss reading assignment.

RESOURCES

Walker. **Machining Fundamentals,** pp. 30-31.

EVALUATION

Written Question
What advantage does the slide caliper rule have over the 6" rule?

Answer
Slide caliper rule can be set to a specific size for repeated measurements.

DUTY: PERFORMING PRECISION MEASUREMENT

TASK: Layout work with combination square

PERFORMANCE OBJECTIVE V-TECS 10

STANDARD: Workpiece msut be layed out to a tolerance of ± 1/64" and/or blueprint specifications.

SOURCE OF STANDARD: Kibbe, et. al. **Machine Tool Practices**, p. 271.

CONDITIONS FOR PERFORMANCE OF TASK:
Furnished with workpiece
Blueprint
Combination square
Scriber
Files
Layout dye
Prick punch
Center punch
Layout hammer

PERFORMANCE GUIDE

1. Deburr and clean workpiece.
2. Coat surface with layout dye.
3. Select reference surface or edge on workpiece
   - a. Check blueprint for reference edge.
   - b. Use finished surface for reference on workpiece.
4. Scribe one end of workpiece.
   - a. Allow room for complete layout on workpiece
   - b. Scribe perpendicular to reference edge.
5. Scribe centerlines of arcs and holes.
6. Prick punch hole locations on centerlines.
7. Scribe arcs and holes, if necessary.
8. Layout outline of workpiece.
9. Check layout against blueprint.
   - a. Approve workpiece, or
   - b. Correct layout by recoating workpiece with layout dye and completely layout again until all designated dimensions are within tolerance specified.

LEARNING ACTIVITIES

1. Explain operation and nomenclature of combination square.
2. Discuss instructions on job sheet and blueprint.
3. Demonstrate use of square head, center head, and protractor head.
4. Emphasize importance of reference edge and how to make corrections.
5. Have students perform measurements on workpiece.

RESOURCES

Anderson and Tatro. **Shop Theory**, pp. 59-60.
Krar, et. al. **Technology of Machine Tools**, pp. 55-57.
Lascoe, et. al. **Machine Shop Operations and Setups**, (3rd edition, pp. 13-14) (4th edition, pp. 15-16).

PERFORMANCE OBJECTIVE V-TECS 10 Continued

EVALUATION

Written Questions

1. Why must a precision square not be used as a working square?
2. Name the four parts of a combination square.

Answers

1. Regular use as a working tool would cause undue wear and scratches and make it lose its precision.
2. a. Blade or rule
   b. Square head
   c. Center head
   d. Protractor head

DUTY: PERFORMING PRECISION MEASUREMENT

TASK: Measure work with spring calipers

PERFORMANCE OBJECTIVE V-TECS 23

STANDARD: The measurement must be within a tolerance of ± 1/64".

SOURCE OF STANDARD: Krar, et. al. **Technology of Machine Tools,** 2nd edition, p. 11.

CONDITIONS FOR PERFORMANCE OF TASK:
Furnished with workpiece
Blueprint and spring calipers
Steel rule

PERFORMANCE GUIDE

1. Select spring caliper.
2. Adjust caliper to workpiece.
    a. Hold one leg against workpiece.
    b. Adjust other leg to lightly touch workpiece.
    c. Hold calipers at right angles to measurement.
    d. Use light touch and do not force calipers.
3. Measure caliper setting.
    a. Hold one leg on end of rule.
    b. Use 1/64th graduations on rule.
    c. Repeat steps 2 and 3 until measurements are within tolerance.
4. Verify measurement within or without tolerance of ± 1/64".
    a. Approve workpiece, or
    b. Reject workpiece.

LEARNING ACTIVITIES

1. Give instructions on use of spring calipers.
2. Demonstrate use of spring calipers.
3. Have students observe and assist other students.
4. Perform measurements on workpiece.
5. Compare measurements with specifications on blueprint.

RESOURCES

Anderson and Tatro. **Shop Theory,** pp. 61-63.
Lascoe, et. al. **Machine Shop Operations and Setups,** (3rd edition, pp. 15-16) (4th edition, pp. 19-20).

EVALUATION

Written Question

Compare accuracy of spring calipers to dial calipers.

Answer

Dial calipers are accurate to 0.001; spring calipers' accuracy depend on instruments used to determine units of measurement.

DUTY: PERFORMING PRECISION MEASUREMENTS

TASK: Layout work with hermaphrodite calipers

PERFORMANCE OBJECTIVE V-TECS 11

STANDARD: A line scribed parallel to an edge of a workpiece and located the center of a round workpiece to an accuracy of ± 1/64" and/or met blueprint specifications.

SOURCE OF STANDARD: Olivo. **Fundamentals of Machine Technology**, pp. 34-35.

CONDITIONS FOR PERFORMANCE OF TASK:

Blueprint
Hermaphrodite calipers
Combination square and blade
Prick punch
Hammer
Layout dye
Round workpiece
Flat workpiece

PERFORMANCE GUIDE

Scribe line parallel to an edge (flat workpiece)

1. Clean and deburr workpiece.
2. Set hermaphrodite calipers on designated setting.
   a. Place hooked leg against end of square blade.
   b. Adjust scriber leg to setting.
   c. Use fine adjustment for final setting.
3. Scribe line parallel to edge of workpiece.
   a. Coat workpiece with layout dye.
   b. Refer to blueprint for reference edge.
   c. Hold hooked leg against edge and move calipers parallel to edge.
   d. Hold calipers perpendicular to edge when scribing line.
4. Check layout to see if layout line meets tolerance specifications.
5. If line not within tolerance, repeat steps 2-4 until workpiece meets designated specifications.

Locate center of round workpiece

1. Clean and deburr workpiece.
2. Coat end of workpiece with layout dye.
3. Set divider leg at required radius.
   a. Measure workpiece and set dividers at one-half diameter of workpiece -- plus
   b. Place hooked leg on end of rule and adjust scribed leg to required radius.
4. Scribe arcs on end of workpiece.
   a. Use four arcs at 90° apart on workpiece.
   b. Hold calipers perpendicular to end of workpiece.
5. Mark center of workpiece in center of arcs with prick punch.

6. Check center location with rule.
    a. Approve workpiece, or
    b. Redo steps 2-6 until workpiece meets designated specifications.

LEARNING ACTIVITIES

1. Explain operation and nomenclature.
2. Explain how to set hermaphrodite calipers.
3. Demonstrate marking lines parallel to edge and locating center of round stock.
4. Have students demonstrate use of calipers.
5. Have students perform measurements on workpiece.
6. Compare measurements with specifications on blueprint.

RESOURCES

Anderson and Tatro. **Shop Theory**, pp. 63-64.

Lascoe, et. al. **Machine Shop Operations and Setups**, (3rd edition, pp. 80-81) (4th edition, pp. 82, 83, 85)

EVALUATION

Written Question

Fill in the blank:

The layout tool that has one leg shaped like a caliper, the other leg is pointed like a divider is called ____________ ____________.

Answers

Hermaphrodite calipers

DUTY: **PERFORMING PRECISION MEASUREMENTS**

TASK: Check work with radius gages

PERFORMANCE OBJECTIVE V-TECS 6

STANDARD: Workpiece must fit gage so no light shows between gage and workpiece.

SOURCE OF STANDARD: Olivo. **Basic Machine Technology**, p. 360.

CONDITIONS FOR PERFORMANCE OF TASK:
Furnished with workpiece
Drawing
Radius gages
Hone
Files

PERFORMANCE GUIDE

1. Select radius gage.
2. Place on centerline of workpiece.
3. Check for light showing between gage and workpiece.
    a. File or hone high spots.
    b. Remachine workpiece if high spots cannot be removed by filing and/or honing.
    c. Regrind tool if necessary.
4. Continue step 3 until workpiece fits gage.

LEARNING ACTIVITIES

1. Give instructions on use and care of radius gages.
2. Discuss instructions on job sheet and blueprint.
3. Demonstrate how to check radii.
4. Have students observe and assist other students in performing measurements on workpiece.
5. Compare measurements with specifications on blueprint.

RESOURCES

Walker. **Machining Fundamentals**, p. 50.
Anderson and Tatro. **Shop Theory**, p. 67.

EVALUATION

Written Question

List two uses for radius gages.

Answers

1. Layout work and inspection
2. Used as template for grinding lathe bits and forming tools.

DUTY: **PERFORMING PRECISION MEASUREMENTS**

TASK: Measure work with outside micrometer

PERFORMANCE OBJECTIVE V-TECS 20

STANDARD: The measured workpiece must be within a tolerance of ± 0.001".

SOURCE OF STANDARD: Olivo. **Fundamentals of Machine Technology**, p. 40.

CONDITIONS FOR PERFORMANCE OF TASK:
Furnished with workpiece
Blueprint
Outside micrometers
Standards
Steel rule

PERFORMANCE GUIDE

1. Clean and deburr workpiece.
2. Select micrometer.
   a. Clean anvil and spindle.
   b. Check size with steel rule.
   c. Check zero setting and adjust, if necessary.
3. Measure workpiece with micrometer.
   a. Use finger tip touch.
   b. Use ratchet for uniform pressure.
   c. Take a measurement 90° from the first measurement on round workpiece.
   d. Take consecutive readings until they match.
   e. Hold micrometer on workpiece when measuring.
   f. If micrometer is moved from workpiece lock spindle.
   g. Include size of micrometer if over one inch.
4. Assure workpiece dimensions within or without tolerance of ± 0.001".
   a. Approve workpiece, or
   b. Reject workpiece.

LEARNING ACTIVITIES

1. Describe micrometer nomenclature.
2. Describe and demonstrate how to hold micrometer and how to check zero setting.
3. Have student observe and assist other students.
4. Discuss reading assignment including all pictures and figures in any or all of the books listed below.
5. Perform measurements on workpiece.
6. Compare measurements with specifications on blueprint.

RESOURCES

Anderson and Tatro. **Shop Theory**, pp. 71-73.
Krar, et al. **Technology of Machine Tools**, pp. 22-27.
Lascoe, et. al. **Machine Shop Operations and Setups**, (3rd edition, pp. 22-27) (4th edition, pp. 22-29).

EVALUATION

Written Questions

1. Describe briefly the principle of the vernier micrometer.
2. Describe the procedure for reading a vernier micrometer.
3. Explain how a 2" micrometer may be checked for accuracy.
4. What are the basic differences between a metric and an inch micrometer?
5. What is the value of one division on: (Using metric micrometer)
    a. The sleeve above the index line?
    b. The sleeve below the index line?
    c. The thimble?

Answers

1. The vernier mechanically divides 1 graduation by 10 to allow mikes to read to .0001".
2. Read the micrometer as a standard micrometer then note the line on the vernier scale that coincides with a line on the thimble.
3. Use 2" gage block or standard and observe that 0 on thimble coincides with index line on sleeve.
4. Metric mikes are accurate to millimeter.
   Inch mikes are accurate to 0.0001".

5. a. Millimeter
    b. .5 millimeter
    c. .01 millimeter

DUTY: PERFORMING PRECISION MEASUREMENT

TASK: Measure work wih inside micrometer

PERFORMANCE OBJECTIVE V-TECS 19

STANDARD: Workpiece must be within ± 0.001" tolerance when inside diameter of the workpiece is measured.

SOURCE OF STANDARD: Heineman and Genevro. **Machine Tools Processes and and Applications,** p. 15.
Olivo. **Fundamentals of Machine Technology,** pp. 49-50.

CONDITIONS FOR PERFORMANCE OF TASK:
Furnished with workpiece
Blueprint
Inside micrometer
Extension rods
Spacing collar
Handle
Steel rule
Outside micrometer
Standards

PERFORMANCE GUIDE

1. Measure inside diameter of workpiece with steel rule.
2. Assemble extension rod in micrometer.
   a. Check shoulder setting.
   b. Check length of inside micrometer with steel rule.
   c. Use spacing collar if necessary.
3. Measure inside diameter of workpiece
   a. Use handle with micrometer
   b. Hold one end of micrometer firmly against side of hole.
   c. Move the other end of the micrometer in arc movements until largest setting is obtained.
4. Read micrometer reading.
   a. Add extension rod length to micrometer reading.
   b. Add spacing collar length if one is used.
   c. Check reading against steel rule measurement.
   d. Take more than one measurement.
5. Assure workpiece as within or without specified tolerance of ± 0.001".
   a. Approve workpiece, or
   b. Reject workpiece.

LEARNING ACTIVITIES

1. Explain how inside micrometer works and compare it to outside micrometer.
2. Instruct on how to measure with inside micrometer.
3. Demonstrate using inside micrometer and assist students in making measurements.
4. Have students perform measurements on workpiece.
5. Have students compare measurements using telescoping gage and inside calipers.

RESOURCES

Anderson and Tatro. **Shop Theory**, p. 74
Krar, et. al. **Technology of Machine Tools**, pp. 17-18.
Lascoe, et. al. **Machine Shop Operations and Setups**, (3rd edition, pp. 27-30) (4th edition, pp. 32-33).

EVALUATION

Written Questions

1. What construction feature compensates for a lock nut on inside micrometers?
2. What precautions must be taken when:
    a. Assembling the inside micrometer and extension rod?
    b. Using the inside micrometer?
3. What is the correct "feel" with an inside micrometer?

Answers

1. The thimble nut is adjusted to a tighter fit on the spindle thread to prevent a change in setting when removing from workpiece.
2. a. Make sure rod (spindle) is in place and cap tightens properly.
    b. Make sure inside micrometer is in alignment with measurement being made.
3. The correct "feel" will have "drag" without binding.

DUTY: PERFORMING PRECISION MEASUREMENTS

TASK: Measure work with thread wires

PERFORMANCE OBJECTIVE V-TECS 26

STANDARD: The work piece must be within a tolerance of ± 0.001" and/or meet blueprint specifications.

SOURCE OF STANDARD: Oberg, et. al. **Machinery's Handbook**, p. 1387.

CONDITIONS FOR PERFORMANCE OF TASK:
Furnished with threaded workpiece
Blueprint
Thread measuring wires
Vernier micrometer calipers
Gage blocks
Machinist's handbook

PERFORMANCE GUIDE

1. Clean and deburr workpiece
2. Select vernier micrometer caliper.
   a. Check micrometer with gage blocks
   b. Adjust micrometer, if necessary.
3. Select thread measuring wires.
   a. Check machinist's handbook for formula.
   b. Calculate "best" wire size.
   c. Check measuring wires with vernier micrometer caliper.
4. Measure workpiece with thread measuring wires.
   a. Place two wires on one side and one on opposite side.
   b. Use light pressure.
5. Verify workpiece dimensions as within or without specified tolerances.
   a. Accept workpiece, or
   b. Reject workpiece.

LEARNING ACTIVITIES

1. Instruct on use of thread wires.
2. Read instruction on job sheet and blueprint.
3. Demonstrate use of wires.
4. Have students observe and assist other students.
5. Perform measurements on workpiece.

RESOURCES

Oberg. **Machinery's Handbook**, pp. 1406, 1421.
Krar, et. al. **Technology of Machine Tools**, pp. 180-182.

EVALUATION

Written Questions

1. What is meant by "best" wire size?
2. Calculate the best wire size and the measurement over the wires for a thread 3/4 -- 10 NC.

PERFORMANCE OBJECTIVE V-TECS 26 continued

Answers

1. The wire size that will give the most accurate measurement using the three-wire method.
2. Calculate G (wire size)

$$G = \frac{.57735}{10}$$

$$G = .0577$$

Calculate M (measurement over the wires)

$$M = D + 3G - \frac{1.5155}{N}$$

$$M = .75 + (3 \times .0577) - \frac{1.5155}{10}$$

$$M = .7715$$

DUTY: **PERFORMING PRECISION MEASUREMENT**

TASK: Measure work with depth gages

PERFORMANCE OBJECTIVE V-TECS 13

STANDARD: Workpiece must meet blueprint specifications and a tolerance of ± 1/64" with a rule depth gage and ± 0.001" with a vernier depth gage.

SOURCE OF STANDARD: Walker. **Machining Fundamentals**, p. 19

CONDITIONS FOR PERFORMANCE OF TASK:
Furnished with blueprint
Rule depth gage
Vernier depth gage
Machinist's handbook
Machined workpiece

PERFORMANCE GUIDE

Rule depth gage

1. Clean and deburr reference surface.
2. Slide rule as far as it will go into hole without disturbing contact of gage head and work.
3. Tighten clamp nut
4. Remove from hole and read depth dimension on rule at junction with gage head.
4. Verify workpiece dimensions within or without specified tolerance.
   a. Accept workpiece, or
   b. Reject workpiece.

Vernier depth gage

1. Refer to machinist's handbook as to how to read vernier scale.
2. Clean and deburr reference surface.
3. Set vernier depth gage base on reference surface and insert rule to bottom of hole.
   a. Hold base firmly on reference surface.
   b. Lock rule on place with lock screw.
   c. Adjust vernier movement to light contact with bottom of rule.
4. Remove gage and read vernier setting.
5. Verify workpiece dimensions as within or without specified tolerance.
   a. Accept workpiece, or
   b. Reject workpiece.

LEARNING ACTIVITIES

1. Explain how to use depth gage.
2. Discuss instruction on job sheet and blueprint.
3. Demonstrate measuring with depth gage.
4. Have students observe and assist other students.
5. Have students perform measurements on workpiece to specifications.
6. Compare measurements with specifications on blueprint.

RESOURCES

Krar, et. al. **Technology of Machine Tools**, p. 21.
Lascoe, et. al. **Machine Shop Operations and Setups**, p. 12.

EVALUATION

Written Question

Compare accuracy of vernier depth gage to rule depth gage.

Answer

Vernier depth gage is accurate to .001" while rule depth gage is accurate to 1/64".

DUTY: **PERFORMING PRECISION MEASUREMENT**

TASK: Measure work with depth micrometer

PERFORMANCE OBJECTIVE V-TECS 14

STANDARD: Depth of slot must measure to a tolerance of ± 0.001".

SOURCE OF STANDARD: Walker. **Machining Fundamentals,** p. 19
Olivo. **Fundamentals of Machine Technology,** pp. 47-48.

CONDITIONS FOR PERFORMANCE OF TASK:
Furnished with blueprint
Depth micrometer
Interchangeable measuring rods
Machined workpiece

PERFORMANCE GUIDE

1. Clean and deburr reference surface.
2. Identify interchangeable measuring rod.
3. Insert interchangeable measuring rod into micrometer.
4. Set micrometer on reference surface and turn thimble until rod touches bottom of slot.
    - a. Hold micrometer base firmly on reference surface.
    - b. Use light touch with rod.
5. Remove micrometer and note reading.
    - a. Note: the depth micrometer reads backwards.
    - b. Take more than one measurement.
    - c. Continue measuring until two or more readings are within designated tolerance.

LEARNING ACTIVITIES

1. Explain how depth micrometer differs from outside micrometer.
2. Demonstrate use of depth micrometer.
3. Observe students making measurements using depth micrometer.
4. Discuss reading assignment (include all pictures and figures) in any or all of the books listed below.
5. Have students perform measurements on workpiece.
6. Compare measurements with specifications on blueprint.

RESOURCES

Krar, et. al. **Technology of Machine Tools,** pp. 20-21.
Lascoe, et. al. **Machine Shop Operations and Setups,** (3rd edition, pp. 30-31) (4th edition, pp. 22-29)

EVALUATION

Written Questions

1. How is the accuracy of a micrometer depth gauge adjusted?
2. How must the workpiece be prepared prior to measuring the depth of a hole or slot with a micrometer depth gauge?
3. Explain the procedure for measuring a depth with a depth micrometer.
4. How does the reading of a depth micrometer differ from that of a standard outside micrometer?

Answers

1. Controlled by nut on end of extension rod.
2. Remove burrs.
3. a. Remove burrs.
   b. Hold the micrometer base firmly against the surface of workpiece.
   c. Rotate thimble until rod touches bottom.
   d. Recheck the micrometer setting, take reading.
4. Read in reverse order.

DUTY: PERFORMING PRECISION MEASUREMENTS

TASK: Measure inside and outside diameter with vernier caliper

PERFORMANCE OBJECTIVE V-TECS 12

STANDARD: Inside and outside diameters of workpiece must measure to a tolerance of ± 0.001".

SOURCE OF STANDARD: Kibbe., et. al. **Machine Tool Practices**, p. 131.

CONDITIONS FOR PERFORMANCE OF TASK:
Furnished with workpiece
Blueprint
Machinist's handbook
Inside-outside vernier caliper
Files
Deburring tool

PERFORMANCE GUIDE

1. Refer to handbook as to how to read vernier scale.
2. Deburr workpiece.
3. Select calipers according to work size.
4. Check calipers for zero setting and adjust, if necessary.
5. Adjust sliding jaw to inside diameter and lock.
6. Take inside diameter measurement by adjusting vernier scale with fine adjustment.
    a. Avoid excessive pressure to prevent springing the jaws.
    b. Keep calipers on centerline for measurement.
    c. Read caliper while in place on the workpiece.
    d. Take at least two separate readings.
    e. Repeat measurements until two measurements are within tolerance.
7. Repeat steps 3-6 for measuring outside diameter until measurements are within tolerance.

LEARNING ACTIVITIES

1. Discuss how to read and/or accuracy of vernier calipers.
2. Discuss instruction on job sheet and blueprint.
3. Demonstrate use of vernier caliper.
4. Have students demonstrate measuring and assist other students.
5. Perform measurements on workpiece using vernier calipers.
6. Compare measurements with specifications on blueprint.

RESOURCES

Krar, et. al. **Technology of Machine Tools**, pp. 14-16.
Lascoe, et. al. **Machine Shop Operations and Setups**, 3rd edition, pp. 34-37

EVALUATION

Written Questions

1. Describe the principle of:
    a. the 25-division vernier
    b. the 50-division vernier
2. Describe the procedure for reading a vernier caliper.

Answers

1. a. The vernier scale on the movable jaw has 25 equal divisions, each representing .001".
   b. The 50 division vernier has 50 divisions which represents .001".
2. a. The last large number above the main scale on the bar and to the left of the vernier scale represents the number of whole inches.
   b. Note the last small number on the bar to the left of the zero on the vernier scale. Multiple this number by .100.
   c. Note how many graduations are showing on the bar between the last number and the zero on the vernier scale. Multiple this number by .025.
   d. Observe which line on the vernier scale coincides with a line on the bar. Multiply this number by .001.

DUTY: **PERFORMING PRECISION MEASUREMENTS**

TASK: Check work with optical comparator

PERFORMANCE OBJECTIVE V-TECS 4

STANDARD: Workpiece must fit the template or comparator chart within a tolerance of ± 0.001" on decimal dimensions and ± 1° on angular dimensions and/or meet blueprint specifications.

SOURCE OF STANDARD: Giesecke, et. al. **Technical Drawing,** 7th ed., p. 339 Kentucky Writing Team, Incumbent Workers and Instructors.

CONDITIONS FOR PERFORMANCE OF TASK:
Furnished with workpiece
Blueprint
Optical comparator
Dial indicator
Template or comparator chart
Micrometer work stage
Measuring rods and tilting centers

PERFORMANCE GUIDE

1. Mount tilting centers.
2. Mount magnification lens in optical comparator.
3. Turn on comparator.
4. Mount workpiece between centers.
    a. Align work with dial indicator
    b. Set centers to helix angle of thread (if required).
5. Mount template or comparator chart on comparator.
6. Measure angle of workpiece.
    a. Focus part in place.
    b. Align part with chart or template.
7. Check dimensions of workpiece.
    a. Mount measuring rods on comparator.
    b. Mount dial indicator on comparator.
    c. Obtain required dimensions by reading the micrometer scales on the right side of the table (x and y movements)
    d. Turn comparator off after completing measurements.
8. Assure that workpiece dimension are within or without designated tolerances.
    a. Approve workpiece, or
    b. Reject workpiece.

LEARNING ACTIVITIES

1. Explain theory of operation and selection of magnification.
2. Demonstrate making a comparison, noting precautions in setting-up workpiece.
3. Review manufacturer's handbook and/or instructions.
4. Discuss study assignments in any or all of the books listed below.
5. Have students perform measurements on workpiece.
6. Compare measurements with specifications on blueprint.

RESOURCES

Anderson and Tatro. **Shop Theory,** pp. 230-231.
Krar, et. al. **Technology of Machine Tools,** pp. 36-38.
Lascoe, et. al. **Machine Shop Operations and Setups,** (3rd edition, p. 216) (4th edition, p. 232).

EVALUATION

Written Questions

1. Define an optical comparator.
2. Why is high amplification necessary in any comparison measurement process?
3. List the advantages of an optical comparator.
4. What precautions are necessary when charts are used on an optical comparator?

Answers

1. Optical comparators project an enlarged shadow onto a screen where it may be compared to lines or a master form.
2. Large amplification permits extremely accurate gauging to be performed even on very small parts.
3. Optical comparators are a fast and accurate means of measuring small, odd-shaped parts which are difficult to measure otherwise.
4. Charts are available in several magnifications, therefore, care must be taken to use a chart of the same magnification as the lens mounted on the comparator.

DUTY: **PERFORMING PRECISION MEASUREMENTS**

TASK: Check work with sine bar

PERFORMANCE OBJECTIVE V-TECS 7

STANDARD: Workpiece must be aligned within ± 5 minutes of blueprint.

SOURCE OF STANDARD: Olivo. **Basic Machine Technology**, p. 1586.
Kibbe, et. al. **Machine Tool Practices**, pp. 206-208.

CONDITIONS FOR PERFORMANCE OF TASK:
Furnished with blueprint
Workpiece
Machinist's handbook
Gage blocks
Sine bar
Surface plate
Angle plate
Clamps
Dial indicator and stand

PERFORMANCE GUIDE

1. Place angle plate on surface plate.
    a. Check angle plate for burrs or chips.
    b. Clean surface plate.
2. Determine angle requirement.
    a. Check blueprint for angle.
    b. Select sine bar.
    c Check machinery's handbook for gage block assembly.
    d. Clean and wring gage blocks.
    e. Place sine bar on gage blocks against angle plate.
3. Mount dial indicator on stand.
4. Set dial indicator against sine bar and set to zero.
5. Clamp workpiece to angle plate.
6. Align workpiece with dial indicator within blueprint specifications.

LEARNING ACTIVITIES

1. Explain relationship of sine function and use of sine bar.
2. Explain obtaining angle requirement on blueprint.
3. Demonstrate use of sine bar and gage blocks.
4. Have students practice using sine bar to mark angles.
5. Discuss reading and study assignments.
6. Have students perform measurements on workpiece.
7. Compare measurements with specifications on blueprint.
8. Repeat or correct measurement not within tolerance.

RESOURCES

Anderson and Tatro. **Shop Theory**, 5th edition, pp. 95-96.
Krar, et. al. **Technology of Machine Tools**, pp. 28-30.
Oberg, et. al. **Machinery's Handbook**, 20th ed., pp. 1590-1596.

EVALUATION

Written Questions

1. Describe the construction and principle of a sine bar.
2. What are the accuracies of the 5" and the 10" sine bars?
3. Calculate the gauge block buildup for a 30° angle.
4. In calculating the angle of a taper, why is the formula

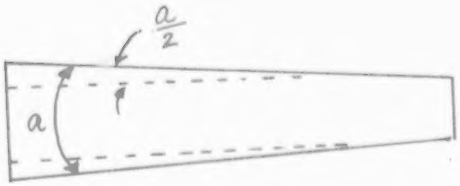
   $\text{Tan}\ \frac{1}{2}\ a = \frac{TPF}{24}$ used, rather than

   $\text{Tan}\ a = \frac{TPF}{12}$?

   Illustrate with a suitable sketch.

Answers

1. Consists of steel bar with two cylinders of equal diameter secured near the ends. The bar becomes the hypotenuse of a right triangle.
2. All 5" sine bars are 5" ± .0002 between centers with face .00005" within 5". All 10" sine bars are 10" ± .00025 between centers with face .00005" within 10".
3. Build-up = 5 x sin 30°
   = 5 x .500
   = 2.500
4. In order to take 1/2 of a included angle given as TPF which has already been multiplied by 12, divide by 24. This is the same as dividing original tangent by 2.



DUTY: **PERFORMING PRECISION MEASUREMENT**

TASK: Measure work with gage blocks

PERFORMANCE OBJECTIVE V-TECS 16

STANDARD: The measurements must be within a tolerance of ± 0.0001" at a temperature of 68° Fahrenheit to 72° Fahrenheit.

SOURCE OF STANDARD: Kibbe, et. al. **Machine Tool Practices**, p. 192.

CONDITIONS FOR PERFORMANCE OF TASK:
Furnished with blueprint.
Workpiece
Gage blocks
Gage pins
Height gage attachment
Surface plate cleaning solution
Lintfree tissue

PERFORMANCE GUIDE

1. Check drawing for required dimensions.
2. Clean workpiece and place on surface plate.
3. Select required gage blocks and attachments.
   a. Calculate gage blocks required.
   b. Use wear blocks.
4. Clean gage blocks.
5. Wring gage blocks.
6. Add attachments to gage blocks.
7. Measure workpiece with gage block assembly.
8. Verify workpiece dimension within or without specified tolerance.
   a. Accept workpiece, or
   b. Reject workpiece.

LEARNING ACTIVITIES

1. Instruct on care, cleaning and wringing gage block.
2. Have students read instructions on job sheet and blueprint.
3. Demonstrate using gage blocks.
4. Have students observe and assist other students.
5. Discuss reading and study assignments.
6. Have students perform measurements on workpiece.
7. Compare measurements with specifications on blueprint.

RESOURCES

Krar, et. al. **Technology of Machine Tools**, pp. 25-27.
Johnson. **General Industrial Machine Shop**, pp. 126-127.

EVALUATION

Written Questions
1. How are gauge blocks stablized and why is this necessary?
2. State five general uses for gauge blocks.
3. For what purpose are wear blocks used?
4. How should wear blocks always be assembled into a buildup?

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5. State the difference between a master set and a working set of gauge blocks.
6. What precautions are necessary when handling gauge blocks in order that the effect of heat on the blocks is minimal?
7. List five precautions necessary for the proper care of gauge blocks.

Answers

1. By "wringing" to make them stay together.
2. a. To check the dimensional accuracy of fixed gauges.
   b. To calibrate adjustable gages.
   c. To set comparators
   d. To set sine bars
   e. Precision layout and tool setups.
3. To prevent wear from occuring on all the blocks.
4. Put wear blocks on outside of ALL setups.
5. Master set used as standard, working set used in shop.
6. Handle them only when necessary for short periods of time.
7. Clean and oil each time they are used.

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DUTY: **PERFORMING PRECISION MEASUREMENTS**

TASK: Layout work on surface plate

PERFORMANCE OBJECTIVE V-TECS 8

STANDARD: Location of positions must be within ± 0.005 for decimal dimensions, ± 1/64" for fraction dimensions and ± 30 minutes on angular dimensions and/or within blueprint specifications.

SOURCE OF STANDARD: Walker. **Machining Fundamentals**, pp. 57-65.

CONDITIONS FOR PERFORMANCE OF TASK:
Furnished with workpiece
Blueprint
Surface plate
Angle plate
Surface gage
Vernier height gage
Scriber
Combination square set
Scribe dividers
Layout dye
Files
Prick punch
Hammer

PERFORMANCE GUIDE

1. Caution: remove all burrs on workpiece
2. Coat surface with layout dye.
   a. Clean workpiece.
   b. Coat surface with dye.
3. Align workpiece
   a. Place angle plate carefully on surface plate.
   b. Align workpiece so that all dimensions can be made from the surface plate.
   c. Mount workpiece and clamp to angle plate (use a straight edge of the workpiece as a base, if possible).
4. Scribe a reference or base line on workpiece.
   a. Use a straight edge on workpiece as base if possible.
   b. Set vernier height gage to blueprint specifications.
5. Scribe lines in accordance with blueprint specifications.
   a. Set vernier height gage to required dimensions.
   b. Scribe all horizontal lines.
   c. Scribe angular lines using protractor.
   d. Scribe arcs and circles with scribe dividers
6. Assure scribed lines are within specified tolerance.

LEARNING ACTIVITIES

1. Explain care and precautions in use of surface plate.
2. Demonstrate how to use angle plates, V-blocks and clamps.
3. Demonstrate making a layout using angle plates and vernier height gage.
4. Have students practice layouts.

PERFORMANCE OBJECTIVE V-TECS 8 continued

5. Discuss reading and study assignments.
6. Compare measurements with specifications on blueprint.

RESOURCES

Lascoe, et. al. **Machine Shop Operations and Setups,** p. 38.
Krar, et. al. **Technology of Machine Tools,** pp. 9, 23-24.
Walker. **Machining Fundamentals,** pp. 59-61.

EVALUATION

Written Questions

1. What is the purpose of a surface plate?
2. Name three types of granite used in making surface plates.
3. State five advantages of granite over cast-iron surface plates.
4. List five points necessary for the care of surface plates.

Answers

1. Provides reference plane for layout, setup, and inspection work.
2. Pink, black, or grey (natural elements in each determine type and color).
3. The advantages of granite are:
    a. They do not rust.
    b. They do not burr.
    c. They are non-magnetic.
    d. They are not appreciably affected by temperature.
    e. Abrasives do not embed themselves in granite as easily.
4. a. Keep clean.
    b. Protect with cover when not in use.
    c. Do not strike with hammer or center punch workpiece on them.
    d. Deburr workpiece.
    e. Slide heavy workpieces onto surface plate rather than placing directly on.

DUTY: **PERFORMING PRECISION MEASUREMENT**

TASK: Measure work on surface plate

PERFORMANCE OBJECTIVE V-TECS 3

STANDARD: The measurement of the workpiece must be accurate to a tolerance of ± 1/64" on fraction dimensions and ± 0.001" on decimal dimensions and/or to blueprint specifications.

SOURCE OF STANDARD: Walker. **Machining Fundamentals**, p. 19.

CONDITIONS FOR PERFORMANCE OF TASK:
Furnished with blueprint
Workpiece
Gage blocks
Height gage
Dial indicator and stand
V-blocks
Surface plate

PERFORMANCE GUIDE

1. Clean surface plate.
    a. Wipe surface plate clean with rag.
    b. Check surface plate for nicks or burns.
    c. Carefully remove any surface defects.
2. Place work on plate.
    a. Caution: extreme care must be exercised in placing and handling work and tools on plate to avoid scratches and nicks to plate.
    b. Caution: when not in use, protect plate with cover.
    c. Caution: All burrs, sharp edges and rough areas on work must be removed prior to placement on surface plate.
    d. Set work on V-blocks.
3. Set up for measurement.
    a. Build gage blocks to blueprint specifications.
    b. Attach dial indicator to stand.
    c. Place assembled dial indicator to plate.
4. Take measurement of workpiece.
    a. Align dial indicator to gage blocks.
    b. Set dial indicator on zero reading.
    c. Place dial indicator against surface to be checked on workpiece.
    d. Record dial indicator measurement.
    e. Accept workpiece as within dimension tolerances, or
    f. Reject workpiece.

LEARNING ACTIVITIES

1. Explain care and precautions in using surface plate.
2. Demonstrate how to use angle plates and accessories.
3. Demonstrate alignment of workpiece with students observing.
4. Discuss reading and study assignment on measuring tools to be used.
5. Have students perform measurements on workpiece.
6. Compare measurements with specifications on blueprint.

PERFORMANCE OBJECTIVE V-TECS 3 continued

RESOURCES

Krar, et. al. **Technology of Machine Tools**, pp. 56-57.
Lascoe, et. al. **Machine Shop Operations and Setups**, p. 38.

EVALUATION

Written Questions

1. How is the accuracy of surface plates usually indicated?
2. Which is more accurate surface gage or height gage? Why?

Answers

1. Variation in flatness from corner to corner in ten thousandth of an inch.
2. Height gage has a scale graduated to .001".
   Surface gage is dependent on other measuring devices to obtain a reading.

DUTY: **PERFORMING PRECISION MEASUREMENTS**

TASK: Check work with surface gage

PERFORMANCE OBJECTIVE V-TECS 9

STANDARD: Workpiece must be within drawing dimensions to a tolerance of ± 1/64".

SOURCE OF STANDARD: Giesecke, et. al. **Technical Drawing**, p. 339.
Kibbe, et. al. **Machine Tool Practices**, p. 363.

CONDITIONS FOR PERFORMANCE OF TASK:
Furnished with workpiece
Blueprint
Surface gage
Combination square
Surface plate
Files
Clamps

PERFORMANCE GUIDE

1. Clean surface plate.
2. Deburr workpiece.
3. Set workpiece on surface plate.
4. Set surface gage to workpiece height.
5. Check height setting of surface gage against combination square
   a. Accept workpiece, or
   b. Reject workpiece.

LEARNING ACTIVITIES

1. Explain the various uses of surface gage.
2. Demonstrate use of surface gage.
3. Observe student demonstration.
4. Discuss reading and study assignments.
5. Have students perform measurements on workpiece.
6. Compare measurements with specifications on blueprint.

RESOURCES

Anderson and Tatro. **Shop Theory**, pp. 64-65.
Krar, et. al. **Technology of Machine Tools**, p. 56.
Lascoe, et. al. **Machine Shop Operations and Setups** (3rd edition, pp. 82-84) (4th edition, pp. 84-85).

EVALUATION

Written Question
How are measurements made with surface gage?

Answer
By using rules, squares or duplications and/or transferring other measurements.

DUTY: **PERFORMING PRECISION MEASUREMENT**

TASK: Measure work with indicators and attachments

PERFORMANCE OBJECTIVE V-TECS 18

STANDARD: The workpiece must be aligned on a work-holding device to a tolerance of ± 0.001".

SOURCE OF STANDARD: Kibbe, et. al. **Machine Tool Practices,** p. 18.
Heineman and Genevro. **Machine Tools Processes and Applications,** p. 15.

CONDITIONS FOR PERFORMANCE OF TASK:
Furnished with workpiece
Blueprint
Precision measuring instruments
Dial indicator and attachments
Work-holding device

PERFORMANCE GUIDE

1. Clean and deburr workpiece.
2. Select indicator and attachment.
3. Mount workpiece in work-holding device.
4. Clamp indicator in position.
5. Adjust workpiece for rough alignment.
6. Contact workpiece lightly with indicator.
7. Set dial indicator on zero.
8. Move indicator or workpiece as required.
9. Check reading on dial indicator.
10. Adjust workpiece and repeat steps 6-9 until workpiece is located within required tolerance.

LEARNING ACTIVITIES

1. Describe operation and accuracy of indicators.
2. Instruct on importance of deburring.
3. Demonstrate how to measure work with indicators.
4. Have students observe and assist other students.
5. Discuss reading and study assignments.
6. Have students perform measurements on workpiece.
7. Compare measurements with specifications on blueprint.

RESOURCES

Kar, et. al. **Technology of Machine Tools,** pp. 23, 24, 32-34.
Lascoe, et. al. **Machine Shop Operations and Setups,** 3rd edition, pp. 41-44.

EVALUATION

Written Questions

1. What is the difference between a dial indicator and a dial test indicator?
2. How may the limits of dimensions be shown on a dial indicator?
3. Compare a perpendicular dial indicator with a universal dial test indicator.
4. State how the accuracy of a dial indicator may be checked.

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PERFORMANCE OBJECTIVE V-TECS 18 continued

Answers

1. Dial indicator has greater range than dial test indicators and sometimes has a continuous-reading scale.
2. Regular range indicators are equipped with plus-minus balanced type dial.
3. Perpendicular has spindle at right angles to dial.
   Universal dial test indicator has contact point that may be set at several positions through 180° arc.
4. Make measurement and compare with micrometer measurement.

DUTY: PERFORMING PRECISION MEASUREMENTS

TASK: Measure work with height gages

PERFORMANCE OBJECTIVE V-TECS 17

STANDARD: Workpiece must be measured to an accuracy of ± 1/64" on fraciton dimension and ± 0.001 on decimal dimension and/or to blueprint specifications.

SOURCE OF STANDARD: Kibbe, et. al. **Machine Tool Practices**, p. 276.

CONDITIONS FOR PERFORMANCE OF TASK:
Furnished with workpiece
Blueprint and precision measuring instruments
Vernier height gage
Offset scriber
Surface plate
Files

PERFORMANCE GUIDE

1. Clean and deburr workpiece.
2. Clean surface plate.
3. Set workpiece and height gage on surface plate.
4. Assemble offset scriber in height gage.
5. Check zero setting of height gage on surface plate.
6. Slide vernier scale so scriber is just above height to be measured on workpiece.
7. Lock vernier scale.
8. Turn fine adjustment until scriber touches workpiece.
9. Lock fine adjustment knob.
10. Take reading on vernier scale.
    a. Add inches from beam.
    b. Use magnifying glass, as required, to read vernier.
11. Note reading within or without specified tolerance.
    a. Approve workpiece, or
    b. Reject workpiece.

LEARNING ACTIVITIES

1. Explain how to use height gage.
2. Read and explain instruction on job sheet and blueprint.
3. Demonstrate using height gage.
4. Observe and assist students in making measurements.
5. Discuss reading and study assignments.
6. Have students perform measurements on workpiece.
7. Compare measurements with specifications on blueprint.

RESOURCES

Krar, et. al. **Technology of Machine Tools**, pp. 23-25, 34.

Lascoe, et. al. **Machine Shop Operations and Setups.** (3rd edition, pp. 37-38) (4th edition, pp. 38-39).

EVALUATION

Written Questions

1. State the two main applications for the vernier height gauge.
2. What accessories are required for a vernier height gauge to check accurately the height of a workpiece?
3. A casting with a machined base is placed on a surface plate to check the accuracy of the hole locations. A plug of the proper diameter is inserted in each hole and a dial indicator gauge mounted on a vernier height gauge is set to a 1" gauge block. The following readings were obtained from the top of each plug.

	Hole Diameter	Reading Obtained	Blueprint Reading
a.	.750	4.360	2.945 ± .005
b.	.500	8.009	6.760 ± .002
c.	.450	8.655	7.432 ± .002
d.	.978	3.275	1.782 ± .002
e.	1.000	6.338	4.831 ± .005

Calculate the height of the center of each hole and determine which holes are not in location.

4. What are the advantages of using a precision height gauge in lieu of a gauge block buildup?
5. What dimension(s) must be subtracted from the reading so that the correct reading for the height of a hole being checked will be obtained?

Answers

1. a. Marking location dimensions.
   b. Making direct measurements.
2. Dial indicator and surface plate.
3. a. 2.985 not in location

   Example (a) computation:

   $$\begin{array}{r} 1.00'' \\ +\ \underline{.375} \\ 1.375'' \end{array} \qquad \begin{array}{r} 4.360'' \\ \underline{-1.375} \\ 2.985'' \end{array}$$

   b. 6.759 correct location
   c. 7.430 correct location
   d. 1.786 not in location
   e. 4.838 not in location
4. Quicker and less clumsy.
5. Initial reading plus half the distance of the hole.

DUTY: PERFORMING PRECISION MEASUREMENT

TASK: Check work with plug and ring gages

PERFORMANCE OBJECTIVE V-TECS 5

STANDARD: Workpiece must be within drawing tolerance of ± 0.001" on decimal dimensions and/or ± 1/64" on fraction dimensions.

SOURCE OF STANDARD: Giesecke, et. al. **Technical Drawing**, p. 283.

CONDITIONS FOR PERFORMANCE OF TASK:
Furnished with workpiece
Blueprint
GO and NO-GO plug gage
GO and NO-GO ring gage

PERFORMANCE GUIDE

1. Clean and deburr workpiece.
2. Check workpiece with GO gage.
3. Acceptable part then checked with NO-GO gage.
4. Repeat steps 2 and 3 with all required gages.
5. Verify workpiece dimensions as within or without designated tolerances
   a. Accept workpiece, or
   b. Reject workpiece.

LEARNING ACTIVITIES

1. Explain accuracy and use of gages.
2. Demonstrate how to use GO NO-GO gages.
3. Have students check several workpieces.
4. Discuss reading and study assignments.
5. Have students perform measurements on workpiece and compare measurements with specifications on blueprint.

RESOURCES

Walker. **Machining Fundamentals**, pp. 43-44.
Anderson and Tatro. **Shop Theory**, pp. 82-83.
Krar, et. al. **Technology of Machine Tools**, pp. 2-6.

EVALUATION

Written Questions

1. What purpose do fixed gauges serve in industry?
2. To what tolerance are fixed gauges finished?
3. If a hole size is to be maintained at 1.750 ± .002, what would be the sizes of the "GO" and "NO-GO" gauges?
4. How are the "GO" and "NO-GO" ends of a cylindrical plug gage identified?
5. What precautions must be observed when a cylindrical plug gauge is used?

PERFORMANCE OBJECTIVE V-TECS 5 continued

Answers

1. Quick means of inspecting and checking a specific measurement.
2. 1/10 the tolerance they are designed to control.
3. GO end = 1.758; NO-GO end = 1.752
4. Stamped GO or NO-GO and sometimes a groove will be cut near "NO-GO" end.
5. Do not force or turn it.

DUTY: PERFORMING PRECISION MEASUREMENT

TASK: Measure work with telescope and hole gages

PERFORMANCE OBJECTIVE V-TECS 25

STANDARD: The workpiece must be within a tolerance of ± 0.001" and/or meet blueprint specifications.

SOURCE OF STANDARD: Kibbe, et. al. **Machine Tool Practices**, p. 170.

CONDITIONS FOR PERFORMANCE OF TASK:
Furnished with workpiece
Blueprint
Telescoping gages
Small hole gages
Micrometer caliper
Micrometer standard

PERFORMANCE GUIDE

1. Clean and deburr workpiece.
2. Select gage for desired measurement.
3. Insert gage in hole or slot and release lock screw.
4. Adjust gage to fit workpiece.
   Small hole gage
   a. Select gage.
   b. Adjust gage until it touches workpiece.
   c. Move gage back and forth to obtain feel of measurement.
   d. Withdraw from workpiece.
   Telescoping gage
   a. Select gage.
   b. Insert into workpiece.
   c. Rock gage to obtain largest measurement and lock gage lightly.
   d. Use downward pressure and roll gage.
   e. Lock gage firmly and check measurement by feel.
5. Measure gage setting with micrometer.
   a. Check micrometer with gage or zero setting.
   b. Avoid excessive pressure with micrometer caliper.
6. Repeat steps 2-5 to verify reliability of measurement.
7. Recommend workpiece as within or without specified tolerances.
   a. Approve workpiece, or
   b. Reject workpiece.

LEARNING ACTIVITIES

1. Instruct on using telescope and hole gages.
2. Read and discuss instructions on job sheet and blueprint.
3. Demonstrate on how to measure with telescope gages, etc.
4. Discuss the study assignment.
5. Have students perform measurements on workpiece.
6. Compare measurements with specifications on blueprint.

RESOURCES

Anderson and Tatro. **Shop Theory**, pp. 65-66.
Krar, et. al. **Technology of Machining Tools**, pp. 18-19.
Lascoe, et. al. **Machine Shop Operations and Setups**, (3rd edition, pp. 234-235) (4th edition, pp. 251-252).

EVALUATION

Written Questions

1. List the steps required to measure a hole with a telescope gauge.
2. What hole defects may be conveniently measured with a dial bore gauge?

Answers

1. a. Measure the hole size and select the proper gauge.
   b. Clean the gauge and the hole.
   c. Depress the plungers until slightly smaller than the hole diameter and clamp them into position.
   d. Insert it into the hole and with the handle tilted upwards slightly, release the plungers.
   e. "Lightly" snug up the knurled knob.
   f. Hold the bottom leg of the telescope gauge in position with one hand.
   g. Move the handle downwards through the center while slightly moving the top leg from side to side.
   h. Tighten the plungers: check the "feel".
   i. Check size with outside micrometers.
2. Grooves, pits and taper

DUTY: PERFORMING PRECISION MEASUREMENT

TASK: Measure work with dial calipers

PERFORMANCE OBJECTIVE V-TECS 15

STANDARD: Workpiece must be within a tolerance of ±0.001".

SOURCE OF STANDARD: Kibbe, et. al. **Machine Tool Practices**, p. 135.

CONDITIONS FOR PERFORMANCE OF TASK:
Furnished with machined workpiece
Blueprint
Dial caliper

PERFORMANCE GUIDE

1. Clean surfaces to be measured and deburred.
2. Check drawing for dimensions.
3. With calipers closed, set the dial indicator on "0".
4. Open calipers until the outside or inside jaws touch the surfaces to be measured.
    a. Measure across centerline of workpiece.
    b. Use light touch.
    c. Keep calipers on workpiece while taking caliper reading.
5. Obtain dimensions by reading the main scale and adding the reading on the dial indicator.
6. Note workpiece dimensions within or without specified tolerance.
    a. Accept workpiece, or
    b. Reject workpiece.

LEARNING ACTIVITIES

1. Instruct on how calipers work and accuracy of measurement.
2. Demonstrate use of dial calipers.
3. Have students observe and assist other students.
4. Discuss reading and study assignment.
5. Have students perform measurements on workpiece.
6. Compare measurements with specifications on blueprint.

RESOURCES

Anderson and Tatro. **Shop Theory**, pp. 60-61.
Krar, et. al. **Technology of Machine Tools**, p. 16.

EVALUATION

Written Question
What is the smallest graduation on dial calipers?

Answer
.001

BENCHWORK

DUTY: PERFORMING BENCHWORK

TASK: Inspect work area for safe working environment

PERFORMING OBJECTIVE V-TECS 38

STANDARD: All unsafe conditions must be reported immediately. All items on Inspection Form must be marked safe or unsafe.

SOURCE OF STANDARD: Kentucky Writing Team, Incumbent Workers and Instructors

CONDITIONS FOR PERFORMANCE OF TASK:
Use performance Guide list and work area.

PERFORMANCE GUIDE

1. Inspect area machine tools
    a. Guards/safety device
    b. Control location
    c. Power transmission and drive mechanisms
    d. Overload devices
    e. Exhaust/ventilation (when applicable)
    f. Clean/clear of metal pieces
    g. Attachments/accessories
2. Hand tools.
    a. Stored properly
    b. Clean
    c. Guards (when applicable)
3. Personal protection equipment (when applicable)
    a. Foot wear
    b. Eye protection
    c. Head protection
    d. First-aid station
    e. Fire extinguisher
4. Signs -- danger/warning in proper position
5. Floors, passageways, aisles, space around machines
    a. Non-skid mats
    b. Clean
    c. Clear of metal scraps
    d. Clear of pieces of stock
    e. Free from oil, grease, other liquid
    f. Clearly marked
6. Disposal cans
    a. Designated area
    b. Marked
    c. Covered (when applicable)

LEARNING ACTIVITIES

1. Explain the importance of maintaining a safe work area.
2. Using the checklist, have students move around the work area and write down the safety precautions.
3. Identify from the Performance Guide the items which should be on the checklist. Have students check their list and add if necessary.

4. Discuss the procedure for reporting unsafe conditions and to whom.
5. Discuss first aid needed for injuries which may occur and emergency phone numbers.

RESOURCES

Occupational Safety and Health Act (OSHA) Regulations
A safety test which must be kept on file.

EVALUATION

Written Questions

1. Name at least four items for personal protection as a safety precaution when operating equipment.
2. Why should unsafe conditions be reported immediately?

Answers

1. Footwear
   Eye protection
   Head protection
   Ear protection
2. If unsafe conditions are left unreported, a serious accident could take place.

INSPECTION FORM (P.O. 38)

INSPECTION OF WORK AREA FOR SAFE WORKING ENVIRONMENT PART II

FACTORS	EQUIPMENT	CONDITION	
		SAFE	UNSAFE
Signs			
Floors, passageways, aisles, space around machines			
Disposal cans			

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DUTY: PERFORMING BENCHWORK

TASK: Care for hand tools

PERFORMANCE OBJECTIVE V-TECS 30

STANDARD: Hand tools must meet job specifications or manufacturer's standards.

SOURCE OF STANDARD: Walker. **Machining Fundamentals**, p. 67-93

CONDITIONS FOR PERFORMANCE OF TASK:

- Files
- Saws
- Pliers
- Vises
- Hammers
- Chisels
- Screwdrivers
- Wrenches
- Taps
- Dies
- Hand reamers
- Job specifications or manufacturer's standards

PERFORMANCE GUIDE

1. Inspect hand tool and determine damage.
    - a. Cutting tools must be sharp with no broken teeth.
    - b. Clamping tools must have clean jaws and screws.
    - c. Soft jaws must be available for vises.
    - d. Screwdrivers must have correctly shaped blade.
    - e. Punches and chisels must not have mushroom heads.
2. Obtain any needed parts.
    - a. Dismantle and replace damaged part.
    - b. Make required adjustments.
3. Sharpen dull tools.
    - a. Check for mushroom heads.
    - b. Check angle of cutting edge.
    - c. Regrind shape as required.

LEARNING ACTIVITIES

1. Explain care and treatment of hand tools.
2. Demonstrate and explain the use of hand tools.
3. Let students demonstrate and explain the use of hand tools.
4. Discuss reading assignment.
5. Assign a project for skill development, i.e., let students clean and store tools (on a rotating basis) in tool room.

RESOURCES

Walker. **Machining Fundamentals**, Chapter 6, pp. 67-93.
Krar, et. al. **Technology of Machine Tools**, Chapter 3.
Lascoe, et. al. **Machine Shop Operations and Setups**, pp. 45-88.

PERFORMANCE OBJECTIVE V-TECS 30 continued

EVALUATION

Written Question

Name two major points to remember in caring for hand tools.

Answers

1. Use tool for intended purpose for which it was designed.
2. Keep clean and oiled and stored in tool box.

DUTY: PERFORMING BENCHWORK

TASK: Cut material with hand hacksaw

PERFORMANCE OBJECTIVE V-TECS 31

STANDARD: Workpiece must be cut to within 1/32" outside of scribed line.

SOURCE OF STANDARD: Krar, et. al. **Technology of Machine Tools,** p. 106.

CONDITIONS FOR PERFORMANCE OF TASK:
Hand hacksaw frame
Hacksaw blades (18, 24, and 32 pitch)
Workholding device
Layed-out workpiece
Files and blueprint

PERFORMANCE GUIDE

1. Select blade
2. Mount in hacksaw frame
   a. Teeth pointing away from handle
   b. Nominal tension on blade
3. Mount workpiece in work-holding device
4. Saw workpiece to specifications
   a. Notch workpiece with file for start of cut
   b. Protect workpiece from jaws of work-holding device
   c. Saw 1/32" outside of scribed line

LEARNING ACTIVITIES

1. Explain the use and operation of hack saw blades.
2. Demonstrate the use of hack saw.
3. Let students demonstrate and explain use of hack saw.
4. Discuss reading assignment.
5. Assign project for skill development, i.e., sawing stock to be used for other projects.

RESOURCES

Walker. **Machining Fundamentals,** pp. 72-74.
Krar, et. al. **Technology of Machine Tools,** pp. 66-67.
Lascoe, et. al. **Machine Shop Operatins and Setups,** pp. 67-68.

EVALUATION

Written Questions

What pitch hack saw blade should be selected to cut:

1. Tool steel
2. Thin wall tubing
3. Angle iron and copper

Answers

1. Coarse pitch
2. Fine pitch
3. Medium pitch

DUTY: **PERFORMING BENCHWORK**

TASK: Bench file workpiece

PERFORMANCE OBJECTIVE V-TECS 28

STANDARD: The filed workpiece must be within a tolerance of ± 1/64" on fraction dimensions, ± 0.005" on decimal dimensions, ± 1° on angular dimensions and/or within blueprint specifications.

SOURCE OF STANDARD: Walker. **Machining Fundamentals**, p. 19.

CONDITIONS FOR PERFORMANCE OF TASK:

- Assortment of files
- Files chart
- File handles
- File card
- Vise and false jaws
- Steel square
- Bevel protractor
- Measuring instruments
- Workpiece
- Blueprint

PERFORMANCE GUIDE

1. Select file
2. Check file handle
3. Clean file
4. Mount workpiece
5. Test flatness and/or angle of work
6. Check for pinning
7. File to final tolerance repeating steps 5 and 6 as required

LEARNING ACTIVITIES

1. Explain use and theory of operation of files and filing.
2. Demonstrate the use of files.
3. Let students demonstrate and explain the use of different types files.
4. Let students demonstrate and explain pinning.
5. Discuss reading assignment.
6. Assign project for skill development, i.e., file rough-cut workpiece to a given size within ± .005 and ± 1° square.

RESOURCES

Walker. **Machining Fundamentals**, pp. 76-78.
Krar, et. al. **Technology of Machine Tools**, pp. 68-71.
Lascoe, et. al. **Machine Shop Operations and Setups**, pp. 48-54.

EVALUATION

Written Questions

1. Name the most commonly used degrees of coarseness in which files are manufactured.
2. How can "pinning" of file be kept to a minimum?
3. List four points to be observed in caring for files.

Answers

1. Rough, coarse, bastard, second cut, smooth and dead smooth
2. Avoid applying too much pressure
3. Do not store where they will rub together.
   Do not knock file on vise or other metallic object.
   Use file card to clean file.
   Do not use files for prying.

DUTY: PERFORMING BENCHWORK

TASK: Mark locations with prick punch and center punch

PERFORMANCE OBJECTIVE V-TECS 42

STANDARD: Center punch hole located to an accuracy of ± 1/64" and/or to blueprint specifications.

SOURCE OF STANDARD: Walker. **Machining Fundamentals**, pp. 19, 65

CONDITIONS FOR PERFORMANCE OF TASK:
Center punch
Prick punch
Layout hammer or toolmaker's hammer
Magnifying glass
Blueprint and layed-out workpiece

PERFORMANCE GUIDE

1. Check blueprint for hole location
2. Mark center location with prick punch
   a. Check punch for sharpness
   b. Feel intersection of layout lines with point of prick punch
   c. Hold punch in vertical position
   d. Tap lightly with tool maker's hammer
3. Examine punch mark with magnifying glass
4. Correct punch mark, if necessary
   a. Tap prick punch to pull mark over
   b. Point slightly in direction of correction
5. Re-examine punch mark with magnifying glass
6. Center punch hole location
   a. Seat punch in prick punch mark
   b. Tap punch hard for deep punch mark
7. Verify hole locations against blueprint specifications
   a. Approve workpiece, or
   b. Reject workpiece and/or take corrective action

LEARNING ACTIVITIES

1. Explain the use and/or theory of operation of prick punches and center punches.
2. Demonstrate the use of prick punch in locating centers of holes on workpiece.
3. Have students demonstrate the use of punches.
4. Discuss reading assignment.
5. Assign projects for skill development, i.e., refer to **Technology of Machine Tools,** Figure 2-23, page 60 or use a teacher-made drawing with holes and curved surfaces.

RESOURCES

Walker. **Machining Fundamentals**, pp. 65.
Krar, et. al. **Technology of Machine Tools**, pp. 58-60.
Lascoe, et. al. **Machine Shop Operations and Setups**, p. 77.

PERFORMANCE OBJECTIVE V-TECS 42 continued

EVALUATION

Written Question

How does a prick punch differ from a center punch?

Answer

A Prick punch has a keen point and is used for layout.
A Center punch has a 60° point and is used to start drill bits.

DUTY: PERFORMING BENCHWORK

TASK: Drill holes with portable drill

PERFORMANCE OBJECTIVE V-TECS 33

STANDARD: The drilled hole must be within a tolerance of ± 1/64" and/or meet blueprint specifications.

SOURCE OF STANDARD: Kentucky Writing Team, Incumbent Workers and Instructors.

CONDITIONS FOR PERFORMANCE OF TASK:
- Portable drill
- Drills
- Center punch
- Hammer
- Square
- Work-holding device
- Drill gage
- Workpiece
- Blueprint

PERFORMANCE GUIDE

1. Locate and center punch hole in workpiece
2. Mount workpiece in work-holding device
3. Select drill
    a. Check sharpness
    b. Check drill size with drill gage
4. Mount drill in portable drill
    a. Check for ground on portable drill
    b. Avoid moisture on floor
    c. Tighten drill in two places on drill chuck
5. Drill hole in workpiece
    a. Wear safety glasses
    b. Hold portable drill perpendicular to workpiece
    c. Check speed of portable drill
    d. Brace feet for steady position
    e. Reduce feed pressure as drill penetrates workpiece
    f. Deburr hole
6. Verify drilled hole within or without designated dimension
    a. Accept workpiece, or
    b. Reject workpiece

LEARNING ACTIVITIES

1. Explain the use of portable drills.
2. Demonstrate the use of portable drills including safety precautions.
3. Let students demonstrate the use of portable drills.
4. Have students demonstrate and explain safe practices and cutting speed.
5. Assign projects for skill development, i.e., drill gage with 6 common fractional sizes.

PERFORMANCE OBJECTIVE V-TECS 33 continued

RESOURCES

Walker. **Machining Fundamentals,** pp. 100, 106.
Krar, et. al. **Technology of Machine Tools,** pp. 124-126.
Toboldt and Johnson. **Automotive Encyclopedia,** p. 19.

EVALUATION

Written Question

Give two safety rules when using hand held electrical drill.

Answer

1. Hold drill with both hands.
2. Make sure drill is properly grounded.

DUTY: PERFORMING BENCHWORK

TASK: Cut threads with hand tap

PERFORMANCE OBJECTIVE V-TECS 32

STANDARD: Tapped workpiece must fit gage or mating screw, be within a tolerance of ± 1/64" and/or meet blueprint specifications.

SOURCE OF STANDARD: McCarthy and Repp. **Machine Tool Technology**, p. 1918.

CONDITIONS FOR PERFORMANCE OF TASK:

Drill press
Work-holding device
Hand taps
Tap wrenches
Reference tables
Square
Center punch
Drills
Lubricant
Hammer
Mating screw or gage
Countersink
Workpiece
Blueprint

PERFORMANCE GUIDE

1. Secure workpiece in work-holding device
2. Locate hole position and center punch
3. Select tap drill and drill hole
   a. Consult reference tables
   b. Clamp work in work-holding device
4. Select tap and wrench
   a. Use caution in selection of size of wrench
   b. Clamp tap in holder
   c. Select taper tap
5. Tap hole
   a. Use lubricant, as required
   b. Deburr hole (countersink to thread depth)
   c. Start tap in hold
   d. Check alignment with square
   e. Turn one full turn clockwise (RH threads)
   f. Back up slightly to break chips
   g. Tap hole through and clean out hole
   h. For blind hole, clean out more than once
6. Verify tapped hole with gage or mating screw and with blueprint specifications

PERFORMANCE OBJECTIVE V-TECS 32 continued

LEARNING ACTIVITIES

1. Explain the theory of selecting tap drills and taps.
2. Demonstrate the selection of tap drills and taps.
3. Have students demonstrate and explain the use of taps and tap drills.
4. Discuss reading assignments.
5. Assign appropriate project for skill development such as tap gage with common sizes 1/4 to 5/8 NC threads.

RESOURCES

Walker. **Machining Fundamentals**, pp. 116, 490-491.
Krar, et. al. **Technology of Machine Tools**, pp. 72-74, 485.
Lascoe, et. al. **Machine Shop Operations and Setups**, pp. 59-64.

EVALUATION

Written Questions

1. Define "tap drill" as used in tapping.
2. Give the names of taps that make up a "set" of three.

Answers

1. The correct size drill used in making hole to be tapped.
2. a. Tapered (starting)
   b. Plug
   c. Bottoming

DUTY: PERFORMING BENCHWORK

TASK: Cut threads with die

PERFORMANCE OBJECTIVE V-TECS 56

STANDARD: Threaded work must fit a GO NO-GO gage and be within a tolerance of ± 1/64" in length and/or meet blueprint specifications.

SOURCE OF STANDARD: Kibbe, et. al. **Machine Tool Practices**, p. 83.
Walker. **Machining Fundamentals**, p. 19.

CONDITIONS FOR PERFORMANCE OF TASK:
- Assorted dies
- Die stock
- Lubricant
- Measuring tools
- GO NO-GO thread plug gage
- Work-holding device
- Square
- Layout die
- Scriber
- Workpiece
- Blueprint

PERFORMANCE GUIDE

1. Check blueprint for size and length of thread
2. Select die and die stock
3. Prepare workpiece for threading
   a. Grind or machine bevel on end
   b. Grind or machine 0.003" to 0.005" undersize
   c. Mount workpiece in work-holding device
   d. Mark off length of thread
4. Thread workpiece with die
   a. Use lubricant
   b. Start on chamfered part of die
   c. Start die square with workpiece
   d. Check occasionally with square
   e. Press down and turn one revolution, then back up one-half a turn
   f. After a few threads are made, check with gage
   g. Adjust die, if necessary
   h. Thread to finished length
   i. If threads run to shoulder, reverse die on workpiece and thread to shoulder
5. Check workpiece with GO NO-GO thread plug gage
6. Assure workpiece within or without specified tolerances
   a. Approve workpiece, or
   b. Reject workpiece and/or take corrective action

LEARNING ACTIVITIES

1. Explain theory of selecting die and die stock and size of workpiece.
2. Demonstrate selection of dies and methods of determining size of workpiece to be threaded.

3. Let students demonstrate selection of die using charts and blueprint specifications.
4. Have students demonstrate cutting standard threads using hand dies.
5. Discuss reading assignment.

RESOURCES

Walker. **Machining Fundamentals**, p. 84.
Krar, et. al. **Technology of Machine Tools**, pp. 179-181.
Lascoe, et. al. **Machine Shop Operations and Setups**, pp. 66, 489.

EVALUATION

Written Question

Fill in the blank:

The ________________ ________ ________ has an adjusting screw which permits adjusting over and under size threads.

Answer

adjustable split die

DUTY: PERFORMING BENCHWORK

TASK: Ream holes with hand reamers

PERFORMANCE OBJECTIVE V-TECS 44

STANDARD: Hole must be hand reamed to a tolerance of $^{+0.0005''}_{-0.0000''}$ and/or to blueprint specifications.

SOURCE OF STANDARD: Oberg, et. al. **Machinery's Handbook,** 21st ed., p. 1644.

CONDITIONS FOR PERFORMANCE OF TASK:

- Work-holding device
- Reamers
- Square
- Drill press
- Tap wrench
- Stub center
- Lubricant
- Precision measuring instruments
- GO and NO-GO plug gage
- Blueprint
- Drill Press
- Workpiece

PERFORMANCE GUIDE

Hand Reaming

1. Secure workpiece to work-holding device
2. Select reamer
3. Mount reamer in tap wrench
4. Ream hole
    a. Check for squareness with workpiece
    b. Use lubricant if applicable
    c. Turn clockwise direction only
    d. Use slight downward pressure
5. Check reamed hole with GO and NO-GO gage or measuring instruments
    a. Approve workpiece, or
    b. Reject workpiece

Hand Reaming with Drill Press

1. See steps 1-3 above: Hand Reaming
2. Mount stub center in drill press spindle
3. Align stub center to hole in workpiece on machine table (clamp)
4. Align stub center with reamer center hole
5. Ream hole
    a. Use lubricant, if applicable
    b. Turn in clockwise direction only
    c. Keep pressure down on hand feed
6. Check reamed hole with GO and NO-GO gage or measuring instruments
    a. Approve workpiece, or
    b. Reject workpiece

PERFORMANCE OBJECTIVE V-TECS 44 continued

LEARNING ACTIVITIES

1. Explain the use and/or theory of operation of hand reamers, manually and with aid of drill press.
2. Demonstrate the use of hand reamers.
3. Demonstrate and/or explain checking for squareness and turning direction and downward pressure.
4. Have students demonstrate and explain the use of hand reamers.
5. Discuss reading assignment.

RESOURCES

Walker. **Machining Fundamentals**, pp. 82, 113.
Anderson and Tatro. **Shop Theory**, 5th edition, pp. 120-121.
Krar, et. al. **Technology of Machine Tools**, pp. 75-76, 129-132.
Lascoe, et. al. **Machine Shop Operations and Setups**, pp. 113, 131, 231.

EVALUATION

Written Question

Why should reamers be turned the same way going in and coming out?

Answer

Reamers should be turned the same way to prevent keen edges from being chipped.

DUTY: **PERFORMING BENCHWORK**

TASK: Work and shape metal with handheld tools

PERFORMANCE OBJECTIVE V-TECS 55

STANDARD: Metal must be worked and shaped to a tolerance of ± 1/64" and/or blueprint specifications.

SOURCE OF STANDARD: McCarthy and Smith. **Machine Tool Technology,** p. 49.

CONDITIONS FOR PERFORMANCE OF TASK:
Work-holding device
Grinding wheel
Air grinder
Air supply
Chuck wrench
Portable drill with tool and attachments
Hand chisels
Punches
Hammers
Measurement devices
Blueprint
Workpiece

PERFORMANCE GUIDE

Highspeed Air Grinder

1. Secure grinding wheel in chuck
2. Check air supply
3. Connect grinder to air supply
4. Secure workpiece in holding device
5. Shape workpiece to specifications (wear goggles)

Shape and Work To Specifications

1. Use portable hand drill with proper tool/attachments (use goggles)
2. Select and use sharpened hand chisels and punches and hammers as necessary
3. Shape and work to job specifications
4. Measure for accuracy
5. Repeat step 3 until workpiece is within tolerance

LEARNING ACTIVITIES

1. Explain the use of hand held grinders (high speed air and electrical grinder).
2. Demonstrate grinding using high speed air grinder.
3. Demonstrate use of chisels and punch in forming metal to job specifications.
4. Have students demonstrate shaping and grinding workpiece to specifications.
5. Discuss work hardening and metal fatigue.

RESOURCES

Walker. **Machining Fundamentals**, p. 147.
Krar, et. al. **Technology of Machine Tools**, pp. 127-128.
Lascoe, et. al. **Machine Shop Operations and Setups**, pp. 55-56.

EVALUATION

Written Question

Give two safety rules for using air grinders.

Answer

1. Wear safety glasses or goggles
2. Make sure guards are in place.

DUTY: PERFORMING BENCHWORK

TASK: Test workpiece with hardness tester

PERFORMANCE OBJECTIVE V-TECS 54

STANDARD: Readings taken must be within 2 points in 3 readings.

SOURCE OF STANDARD: Heineman and Genevro. **Machine Tools Processes and Applications,** p. 352.
Oberg, et. al. **Machinery's Handbook,** 21st ed., p. 2127-2134.

CONDITIONS FOR PERFORMANCE OF TASK:
Rockwell Hardness tester
Anvils
Penetrators
Test blocks
Steel samples
Cast iron sample
Abrasive paper

PERFORMANCE GUIDE

1. Identify material to be tested
2. Select weight, penetrator, scale, and anvil
3. Test machine with test block
4. Adjust, if necessary
5. Remove scale from workpiece
6. Place workpiece on anvil
7. Apply minor load and set dial on zero
8. Apply major load letting needle come to a stop
9. Release major load
10. Read hardness number on scale
11. Repeat steps 6-10 in several places on workpiece
12. Record readings
13. For each sample do steps 1-12
14. Obtain three readings within two points on each sample

LEARNING ACTIVITIES

1. Explain the use and theory of hardening steel and its alloys.
2. Demonstrate the use of hardness testers and conversion charts.
3. Demonstrate and explain how to identify material to be tested using visual clues.
4. Have students demonstrate the use of hardness tester and compare to conversion chart.
5. Discuss reading assignment.

RESOURCES

Walker. **Machining Fundamentals,** pp. 384-386.
Krar, et. al. **Technology of Machine Tools,** pp. 402, 421-424.
Lascoe, et. al. **Machine Shop Operations and Setups,** pp. 418, 419, 431.

PERFORMANCE OBJECTIVE V-TECS 54 continued

EVALUATION

Written Question

How does Rockwell hardness tester measure hardness?

Answer

The weight causes the ball penetrator to depress metal, the more penetration the softer the metal.

DUTY: PERFORMING BENCHWORK

TASK: Test workpiece for hardness without hardness tester

PERFORMANCE OBJECTIVE V-TECS 53

STANDARD: Workpiece must be determined as machinable by cutting tools or must be machined by abrasives or carbide tools.

SOURCE OF STANDARD: Kentucky Writing Team, Incumbent Workers and Instructors.
Heineman and Genevro. **Machine Tools Processes and Applications,** pp. 351-353.

CONDITIONS FOR PERFORMANCE OF TASK:
Furnished with workpiece and files

PERFORMANCE GUIDE

1. Select fine 3 cornered file
2. Test workpiece with file
    a. Use corner of workpiece, if possible
    b. File on workpiece at non-critical point, if possible
3. Determine hardness of work
4. Recommend machinability of workpiece

LEARNING ACTIVITIES

1. Explain theory of hardening steel and alloys and the units of mesure in indicating hardness.
2. Demonstrate the use of files to determine hardness.
3. Have students demonstrate and explain use of files to determine approximately hardness.
4. Have students determine if the workpiece is machinable on basis of hardness test.
5. Explain how to use hardness conversion tables.

RESOURCES

Walker. **Machining Fundamentals,** pp. 384, 386.
Krar, et. al. **Technology of Machine Tools,** pp. 402, 421.
Lascoe, et. al. **Machine Shop Operations and Setups,** pp. 432.

EVALUATION

Written Question
How may hardness be determined by using a file?

Answer
A file test indicates that the workpiece is softer or harder than the file.

DUTY: **PERFORMING BENCHWORK**

TASK: Polish metal

PERFORMANCE OBJECTIVE V-TECS 43

STANDARD: Workpiece polished to blueprint specifications.

SOURCE OF STANDARD: Oberg, et. al. **Machinery's Handbook,** 21st ed., p. 2053.
Olivo. **Basic Machine Technology,** pp. 379, 382.

CONDITIONS FOR PERFORMANCE OF TASK:
Grinder or buffer
Lathe
Assortment of abrasive papers
Abrasive
Surface finish scale
Workpiece
Blueprint

PERFORMANCE GUIDE

Determine polishing method (machine and/or hand)

Machine (Lathe)

1. Mount workpiece in lathe
2. Set spindle speed three times rpm used for turning (size and shape of part may require less speed)
3. Select abrasive paper
4. Polish workpiece
    a. Use file with handle to back up pressure on workpiece
    b. Use long overlapping strokes
    c. Check diameter and finish frequently
    d. Use successively finer grit paper for finish cuts
5. Check workpiece against blueprint specifications
    a. Approve workpiece, or
    b. Reject workpiece

Machine (Buffer)

1. Select buffing wheel and compound
2. Remove tool rest if one is on machine
3. Buff workpiece
    a. Apply compound to revolving wheel
    b. Hold workpiece firmly against buffing wheel
    c. Do not point any part of workpiece up into the revolving wheel
    d. Use pressure at center of wheel or below center
    e. Stand firmly braced and hold work tightly
    f. Do not use gloves or long sleeves
    g. Check surface frequently for imperfections still showing
4. Check workpiece against blueprint specifications
    a. Approve workpiece, or
    b. Reject workpiece

PERFORMANCE OBJECTIVE V-TECS 43 continued

LEARNING ACTIVITIES

1. Explain the use and/or theory of operation of polishing on lathe, buffing machine, and drill press.
2. Demonstrate the use of abrasives, buffing compound, crocus cloth.
3. Have student demonstrate buffing a finished project on lathe.
4. Have students demonstrate polishing on drill press and buffer machine.
5. Assign projects for skill development, i.e., a student made project or rusty tools and machine parts.

RESOURCES

Walker. **Machining Fundamentals,** pp. 193, 322.
Anderson and Tatro. **Shop Theory,** 5th edition, p. 454.
Krar, et. al. **Technology of Machine Tools,** p. 161.
Lascoe, et. al. **Machine Shop Operations and Setups,** p. 199.

EVALUATION

Written Question

Why should an abrasive back used on band saw machine require a back support?

Answer

To withstand the pressure of workpiece.

DUTY: **PERFORMING BENCHWORK**

TASK: Grind part with hand grinder

PERFORMANCE OBJECTIVE V-TECS 34

STANDARD: Ground surface must meet blueprint specifications.

SOURCE OF STANDARD: Oberg, et. al. **Machinery's Handbook,** 21st ed., pp. 2034-2037.

CONDITIONS FOR PERFORMANCE OF TASK:
Portable grinder
Wheel assortment
Work-holding device
Grinding wheel chart
Workpiece
Blueprint

PERFORMANCE GUIDE

1. Mount workpiece in work-holding device
2. Check blueprint for surface to be ground
3. Select grinding wheel
   a. Check speed of grinder
   b. Check type of finish required
   c. Check chuck size of grinder
   d. Ring test wheel
4. Mount grinding wheel on grinder
5. Grind workpiece
   a. Wear safety glasses
   b. Use guard on wheel
6. Check ground surface and measure workpiece
   a. Approve workpiece, or
   b. Reject workpiece and/or take corrective action

LEARNING ACTIVITIES

1. Explain the use of various hand grinders.
2. Demonstrate the use of the hand grinder.
3. Demonstrate and explain use of grinding wheels and speeds.
4. Let students demonstrate and explain use of hand grinder and grinding wheels.
5. Assign projects for skill development.

RESOURCES

Walker. **Machining Fundamentals,** p. 147.
Krar, et. al. **Technology of Machine Tools,** pp. 127-128.
Lascoe, et. al. **Machine Shop Operations and Setups,** pp. 55-56, 182.

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PERFORMANCE OBJECTIVE V-TECS 34 continued

EVALUATION

Written Question

Name two important safety rules operators should adhere to while using hand grinders.

Answers

1. Wear goggles
2. Check wheels to be sure they are rated to run no faster than grinder speeds.

DUTY: PERFORMING BENCHWORK

TASK: Broach workpiece with broaching tool

PERFORMANCE OBJECTIVE V-TECS 29

STANDARD: The workpiece must be within a tolerance of ± 0.001" on decimal dimensions and ± 1/64" on fraction dimensions and/or meet blueprint specifications.

SOURCE OF STANDARD: Kibbe, et. al. **Machine Tool Practices**, p. 32.
Giesecke, et. al. **Technical Drawing**, p. 339.

CONDITIONS FOR PERFORMANCE OF TASK:
Arbor press
Broaching tools
Work supports
Broach guides
Precision measuring instruments
Blueprint
Workpiece

PERFORMANCE GUIDE

1. Clean and deburr workpiece
2. Mount work and supports on arbor press
3. Select broaching tool and guides
4. Align broaching tool on workpiece
    a. Check ram wear on arbor press
    b. Check vertical alignment of broaching tool
5. Press broaching tool through workpiece
    a. Use lubricant except on cast iron
    b. Repeat cut with shims if necessary
6. Check measurement of workpiece
    a. Accept workpiece, or
    b. Reject workpiece and/or take corrective action

LEARNING ACTIVITIES

1. Explain the use and theory of operation of broaching.
2. Demonstrate the use of broaches.
3. Let students demonstrate and observe other students using broaches.
4. Let students demonstrate and explain use of alignment and shims.
5. Discuss reading assignments.

RESOURCES

Walker. **Machining Fundamentals**, pp. 223-225.
Krar, et. al. **Technology of Machine Tools**, pp. 76-77.

EVALUATION

Written Question
What is an advantage of broaching?

Answer
Broaches will machine almost any irregular shape parallel to broaching axis.

DUTY: **PERFORMING BENCHWORK**

TASK: Locate holes with transfer screws and transfer punches

PERFORMANCE OBJECTIVE V-TECS 41

STANDARD: Located holes must meet blueprint specifications.

SOURCE OF STANDARD: Krar, et. al. **Technology of Machine Tools**, p. 135.
Walker. **Machining Fundamentals**, p. 19.

CONDITIONS FOR PERFORMANCE OF TASK:
Transfer screws
Transfer punches
Hammer
Pliers
Template
Hex socket wrenches
Clamps
Work-holding device
Scribe dividers
Square blade
Workpiece
Blueprint

PERFORMANCE GUIDE

1. Place workpiece in work-holding device
2. Check blueprint for location and size of holes
3. Select transfer tools
    a. On threaded holes use transfer screws
    b. On straight holes use transfer punches
4. Locate holes on workpiece from template
    a. Insert transfer screws, if required (extend 1/32")
    b. Position template over workpiece
    c. Clamp template to workpiece for transfer punches
    d. Insert transfer punch in template hole
    e. Tap transfer tool lightly with hammer
    f. Remove template
    g. Center punch marks left by transfer punch or screw
5. Verify hole locations against blueprint specifications
    a. Accept workpiece, or
    b. Reject workpiece

LEARNING ACTIVITIES

1. Explain the use and/or theory of operation of transferring hole locations.
2. Demonstrate the use of transfer screws and punches.
3. Have students select the transfer device needed per specifications.
4. Have students demonstrate and explain the use of transfer screws and punches.
5. Assign a project for skill development, i.e., supply student with workpiece that has two or more holes and another workpiece on which to transfer and drill holes.

RESOURCES

Krar, et. al. Technology of Machine Tools, p. 135.

EVALUATION

Written Question

What is the advantage of using transfer punches and screws?

Answer

Transfer punches and screws are faster and more convenient than tedious layout of pattern.

DUTY: **PERFORMING BENCHWORK**

TASK: Remove and install dowel pins

PERFORMANCE OBJECTIVE V-TECS 45

STANDARD: Dowel pins should be within blueprint specifications and/or a tolerance of ± 1/64" on fraction dimensions and ± 0.001" on decimal dimensions.

SOURCE OF STANDARD: Oberg, et. al. **Machinery's Handbook,** 21st ed., pp. 1115-1118.
Walker. **Machining Fundamentals,** p. 19.

CONDITIONS FOR PERFORMANCE OF TASK:
Dowel pins
Drills
Reamers
Drill press
Screw extractor
Pin punches
Hammer
Pliers
Tap wrench
Lapping compound
Machinist's handbook
Measuring instruments
Workpiece
References
Blueprint

PERFORMANCE GUIDE

1. Remove damaged dowel pins with pin punches, if possible.
2. Remove damaged dowel pin with screw extractor, if necessary
   a. Select screw extractor and drill
   b. Center punch and drill hole in pin for extractor
   c. Remove pin with extractor
   d. Examine hole for damage
3. Replace dowel pins(s)
   a. Check use of dowel pin
   b. Consult handbook for type to use
   c. For hardened pins and soft workpiece, ream .001" undersize and lap to fit
4. Check location of and fit of parts that mate against designated tolerances
   a. Accept workpiece, or
   b. Reject workpiece and/or take corrective action

LEARNING ACTIVITIES

1. Explain the use of tapered, spring rolled pins.
2. Demonstrate the installation of dowel pins.
3. Demonstrate and explain using pin extractors and tapered reamers.
4. Have students demonstrate the installation of dowel pins.
5. Discuss reading assignment.

RESOURCES

Walker. **Machining Fundamentals**, p. 360.

EVALUATION

Written Question

What tool is used to make the holes tapered when installing tapered pins?

Answer

Tapered reamers

DUTY: **PERFORMING BENCHWORK**

TASK: Remove broken drills and taps

PERFORMANCE OBJECTIVE V-TECS 46

STANDARD: Workpiece must have broken tools removed and meet blueprint specifications.

SOURCE OF STANDARD: Olivo. **Basic Machine Technology**, p. 151.

CONDITIONS FOR PERFORMANCE OF TASK:

Drills
Taps
Tap extractors
Tap wrench
Hammer
Punches
Drill press
Heat treat oven
EDM machine
Pliers
Blueprint and workpiece with broken drill and broken tap

PERFORMANCE GUIDE

Broken tap

1. Check blueprint for tap size
2. Select tap extractor
    a. Note number of flutes
    b. Check fingers of extractor
3. Remove broken tap
    a. Check RH or LH threads
    b. If tap extends above workpiece surface use pliers to remove tap
    c. Extend fingers completely into flutes
    d. Slide sleeve down against workpiece
    e. Use lubricant, if necessary
    f. Watch for fractured pieces
    g. Work tap back and forth with removal
    h. Use EDM machine on unremovable taps
4. Clean out tapped hole and retap

Broken Drill

1. Check size of broken drill
2. Use pliers, if possible, to lift and twist out drill
3. If through pilot hole is available drive out drill with pin punch
4. Anneal drill; if workpiece can't be damaged
5. Drill out broken drill

LEARNING ACTIVITIES

1. Explain theory of removing broken drills and taps.
2. Demonstrate the use of tap extractor and/or EDM machine.
3. Demonstrate and/or explain annealing and drilling out broken taps and drills.

4. Have students demonstrate and explain the use of tap extractors.
5. Assign projects for skill development, i.e., let student attempt to remove taps when they break.

RESOURCES

Walker. **Machining Fundamentals**, pp. 88, 427-428.
Krar, et. al. **Technology of Machine Tools**, pp. 449-455, 73-74.
Lascoe, et. al. **Machine Shop Operations and Setups**, pp. 64, 467.
Crouse. **The Auto Book**, p. 35.

EVALUATION

Written Question

What is the advantage of using the EDM in removing broken taps?

Answer

The EDM burns tap out and leaves hole the same dimension.

DUTY: **PERFORMING BENCHWORK**

TASK: Remove damaged screws

PERFORMANCE OBJECTIVE V-TECS 47

STANDARD: The fit of the original tapped hole must be maintained.

SOURCE OF STANDARD: Kentucky Writing Team, Incumbent Workers and Instructors.
Giesecke, et. al. **Technical Drawing,** 7th ed., p. 159.

CONDITIONS FOR PERFORMANCE OF TASK:
Electric drill or drill press
Assortment of drills
Center punch
Hammer
Tap drill chart
Taps
Tap wrench
Screw extractors
Workholding device
Lubricant
Center drill
Workpiece having a damaged screw

PERFORMANCE GUIDE

1. Secure workpiece in work-holding device
2. Center punch damaged screw
3. Center drill damaged screw
4. Check thread for RH or LH
5. Select drill and screw extractor
6. Removed damaged screw
    a. Insert screw extractor in drilled hole
    b. Turn gently using downward force
    c. Apply lubricant around the threads of screw
    d. Turn counterclockwise for RH threads (reverse direction for LH threads)
7. Clean hole and re-thread with tap to original hole specifications

LEARNING ACTIVITIES

1. Explain the use of punches and drills to remove broken screws.
2. Demonstrate the use of screw extractor.
3. Have students demonstrate the use of screw extractor.
4. Discuss reading assignments.
5. Assign projects for skill development, i.e., furnish the students with workpiece having a damaged screw and let them select the best way to remove screw.

RESOURCES

No printed resources available.

EVALUATION

Written Question

Why is it important to determine whether the screw has right or left hand threads when removing damaged screws?

Answer

If it is turned the wrong way the screw will continue to tighten.

DUTY: **PERFORMING BENCHWORK**

TASK: Remove defective machine parts and replace

PERFORMANCE OBJECTIVE V-TECS 48

STANDARD: Parts must be replaced according to manufacturer's manual.

SOURCE OF STANDARD: Kentucky Writing Team, Incumbent Workers and Instructors.

CONDITIONS FOR PERFORMANCE OF TASK:
- Manufacturer's repair and parts manual
- Wrenches
- Punches
- Hammer
- Wheel puller
- Measuring instruments
- Replacement parts
- Machine with defective part

PERFORMANCE GUIDE

1. Study manufacturer's repair and parts manual
2. Turn off electrical power
3. Determine section(s) to be disassembled
4. Determine sequence for disassembly
5. Remove retaining fasteners
6. Remove defective part for inspection
7. Replace or repair defective part
   a. Follow manual sequence
   b. Lubricate as required
8. Replace all fasteners
9. Make adjustments as required
10. Test equipment, making required adjustments
11. Equipment must perform according to manufacturer's manual

LEARNING ACTIVITIES

1. Explain the use of manufacturer's repair manual.
2. Discuss how to select tools necessary to make repairs and demonstrate their use.
3. Have students disassemble defected section and label parts with teacher supervision.
4. Have students replace defective parts and assemble according to manual specifications and make adjustments.
5. Discuss reading assignment.

RESOURCES

Walker. **Machining Fundamentals,** pp. 67-84.
Krar, et. al. **Technology of Machine Tools,** pp. 66, 248-250.
Lascoe, et. al. **Machine Shop Operations and Setups,** pp. 56-59
Manufacturer's Manual

PERFORMANCE OBJECTIVE V-TECS 48 continued

EVALUATION

Written Question

Why is it important to refer to manufacturer's manual?

Answer

To make sure of using the correct specifications in making repairs.

DUTY: **PERFORMING BENCHWORK**

TASK: Replace and adjust machine parts

PERFORMANCE OBJECTIVE V-TECS 50

STANDARD; Machine parts must be replaced and adjusted as directed in job specifications.

SOURCE OF STANDARD: Kentucky Writing Team, Incumbent Workers and Instructors.

CONDITIONS FOR PERFORMANCE OF TASK:

- Wrenches
- Rags
- Cleaner
- Lubricant
- Measuring instruments
- Hammer
- Punches
- Machine manual
- Job specifications

PERFORMANCE GUIDE

1. Secure job specifications
2. Receive inspected, repaired, or replacement part(s)
3. Inspect part(s) usability
4. Determine and secure tools, equipment, and measurement instruments
5. Determine sequence for assembly from machine manual (if applicable)
6. Assemble all parts as required
7. Replace all retaining fasteners as required
8. Lubricate machine
9. Make needed adjustments
10. Check required machine part(s) movement by hand
11. Make refinement adjustments, if necessary
12. Check machine operation in low speed
13. Test machine in all speeds and feeds as necessary
14. Make necessary adjustments
15. Clean work station
16. Clean and return tools, equipment, and measurement instruments to storage

LEARNING ACTIVITIES

1. Explain use of manufacturer's repair manual.
2. Discuss selection of proper tools and demonstrate the use of tools needed to make repairs and adjustments.
3. Have students demonstrate and explain specifications listed in manufacturer's manual.
4. Have students make repairs and adjustments.
5. Discuss reading assignments.

PERFORMANCE OBJECTIVE V-TECS 50 continued

RESOURCES

Walker. **Machining Fundamentals**, pp. 67-84.
Krar, et. al. **Technology of Machine Tools**, pp. 66, 248-250.
Lascoe, et. al. **Machine Shop Operations and Setups**, pp. 56-59.
Manufacturer's Parts Manual

EVALUATION

Written Question

Why should machines on which parts have been replaced be run on low speed initially?

Answer

To prevent extensive damage if adjustments are incorrect. (Breaking in process)

DUTY: **PERFORMING BENCHWORK**

TASK: Scrape bearings and slides

PERFORMANCE OBJECTIVE V-TECS 51

STANDARD: The scraped surface must meet blueprint specifications.

SOURCE OF STANDARD: Kentucky Writing Team, Incumbent Workers and Instructors.
Olivo. **Fundamentals of Machine Technology,** p. 125.

CONDITIONS FOR PERFORMANCE OF TASK:

Surface plate
Scrapers
Grinder
Oilstone
Lubricant
Prussian blue dye
Cleaner
Work-holding device
Blueprint
Workpiece

PERFORMANCE GUIDE

1. Clean and deburr workpiece
2. Select scraper
3. Sharpen scraper
4. Clean surface of workpiece
5. Coat surface plate with Prussian blue
6. Lightly rub workpiece surface on surface plate in a figure eight pattern
7. Place workpiece in work-holding device
8. Scrape Prussian blue spots on workpiece
   a. Remove only 0.002" to 0.003" at a time
   b. Use ½" strokes
   c. Keep scraper sharp
9. Clean workpiece
10. Repeat steps 6-9 until all high spots have been removed

LEARNING ACTIVITIES

1. Explain use and theory for scraping bearings and slides.
2. Demonstrate the use of handscrapers and rubbing pattern.
3. Demonstrate and explain sharpening scrapers.
4. Have students demonstrate and observe other students scraping slides.
5. Check bearings and slides for accuracy using dial indicators and gauges.

RESOURCES

Manufacturer's Manual

EVALUATION

Written Question

What purpose does the Prussian blue serve in scraping bearings and slides?

Answer

High spots can be seen easily.

DUTY: **PERFORMING BENCHWORK**

TASK: Straighten workpiece on arbor press

PERFORMANCE OBJECTIVE V-TECS 52

STANDARD: The workpiece must be straightened within a tolerance of 0.002".

SOURCE OF STANDARD: Kentucky Writing Team, Incumbent Workers and Instructors.

CONDITIONS FOR PERFORMANCE OF TASK:

Arbor press
Dial indicator
Work-holding device
Support blocks
Bent workpiece

PERFORMANCE GUIDE

1. Check workpiece location and amount of runout with dial indicator
2. Mark location on workpiece
3. Mount workpiece on arbor press (with supports)
4. Apply pressure to high point (overbend to allow for spring back)
5. Inspect workpiece with dial indicator
6. Repeat steps 1-5 until workpiece is straightened within a tolerance of 0.002".

LEARNING ACTIVITIES

1. Explain use and theory of operation of dial indicator and straight edges in checking part for straightness.
2. Demonstrate the use of arbor press and sequence for applying pressure.
3. Have students attempt to straighten bent shaft.
4. Have students demonstrate and explain use of measuring devices for checking accuracy of straightening efforts.
5. Discuss reading assignment.
6. Assign project for skill development, i.e., supply a bent shaft to be straightened OR compare straightened workpiece to one that was never bent.

RESOURCES

Walker. **Machining Fundamentals**, p. 196.
Krar, et. al. **Technology of Machine Tools**, pp. 187-188.
Crouse. **The Auto Book**, p. 42.

EVALUATION

Written Question
Which dial indicator would work best in straightening workpiece?

Answer
Test dial indicator.

DUTY: PERFORMING BENCHWORK

TASK: Remove frozen or seized parts

PERFORMANCE OBJECTIVE V-TECS 49

STANDARD: Frozen or seized part must be removed properly without damage to machine or piece of equipment.

SOURCE OF STANDARD: Kentucky Writing Team, Incumbent Workers and Instructors.

CONDITIONS FOR PERFORMANCE OF TASK:
Portable drill
Drill press
Drills
Arbor press
Screw extractors
Penetrating oil
Hammer
Pin punches
Machine or piece of equipment with frozen or seized part

PERFORMANCE GUIDE

1. Remove frozen or seized part
    a. Select proper removal method
        1. Drive out part, or
        2. Drill out part, or
        3. Drill and use screw extractor, or
        4. Press out part
    b. Soak part seized with penetrating oil
    c. Check for set screws and pins holding part
    d. Check for taper and shoulders
2. After removing part verify condition of machine or piece of equipment
    a. Approve repair, or
    b. Reject repair and/or take corrective action

LEARNING ACTIVITIES

1. Explain the use of punches, hammer and heat to remove seized parts.
2. Demonstrate the use of punches and drills to remove seized parts.
3. Demonstrate and explain use of welding torch to make metal expand.
4. Have students demonstrate the use of punches to drive out seized parts.
5. Let students use drills to remove seized parts.

RESOURCES

Toboldt and Johnson. **Automotive Encyclopedia**, p. 14.
Crouse. **The Auto Book**, pp. 40, 42.

EVALUATION

Written Question

Why must hardened parts, such as taps, be annealed before drilling?

PERFORMANCE OBJECTIVE V-TECS 49 continued

Answer

Taps are harder than the drill bits used to remove broken parts. Therefore, taps should be annealed to make them softer before drilling.

DUTY: PERFORMING BENCHWORK

TASK: Lap surfaces

PERFORMANCE OBJECTIVE V-TECS 40

STANDARD: Lapped surface must be within a tolerance of 32 to 16 microinches in roughness average and indicate a maximum total of 0.005" TIR.

SOURCE OF STANDARD: Oberg, et. al. **Machinery's Handbook,** 21st ed., pp. 2044-2389.
Krar, et. al. **Technology of Machine Tools,** pp. 81-83.

CONDITIONS FOR PERFORMANCE OF TASK:
- Lapping block
- Lapping plate
- Assorted abrasives
- Lubricant
- Surface finish gage
- Surface plate
- Dial indicator and holder
- Surface roughness comparison standard
- Machined workpiece
- Blueprint

PERFORMANCE GUIDE

1. Clean and deburr workpiece surface
2. Select lapping block or plate
3. Select lapping powder
   a. If work has not been surface ground use lubricant and 120 grit abrasive
   b. Use roughing lap, if necessary
4. Lap surface
   a. Move lap on surface in figure eight motion
   b. Do not dwell in one spot, cover entire area
   c. Avoid heavy pressure
   d. Never add fresh supply of abrasive
   e. Clean lap and surface before adding abrasive
5. Check lapped surface for finish and accuracy
   a. Use surface finish gage for comparison of surface
   b. Check runout of surface on surface plate with dial indicator
6. Repeat steps 3-5 until surface is within tolerance

LEARNING ACTIVITIES

1. Explain the use and theory of operation of lapping abrasives, lapped finishes and blocks.
2. Demonstrate the lapping of flat and round shapes.
3. Let students explain use of lapping abrasives.
4. Let students demonstrate and explain use of lapping blocks and motion pattern.
5. Discuss reading assignment.

PERFORMANCE OBJECTIVE V-TECS 40 continued

RESOURCES

Krar, et. al. **Technology of Machine Tools**, pp. 77-79.

EVALUATION

Written Question

What effect does using a figure 8 lapping pattern have on workpiece?

Answer

Prevents excessive wear in one spot.

DUTY: **PERFORMING BENCHWORK**

TASK: Install a helical coil wire insert

PERFORMANCE OBJECTIVE V-TECS 39

STANDARD: Rethreaded hole must meet blueprint specifications.

SOURCE OF STANDARD: Oberg, et. al. **Machinery's Handbook,** 21st ed., p. 1235.

CONDITIONS FOR PERFORMANCE OF TASK:
Taps
Helical coil wire screw thread inserts (STI) tables
Assortment of helical coils (STI)
Work-holding device
Pliers
Tap wrench
Cleaner
Lubricant
Drill press
Drills
Workpiece with stripped threaded hole and blueprint

PERFORMANCE GUIDE

1. Secure workpiece in work-holding device
2. Select tap drill (consult helical coil wire screw thread insert table)
3. Mount drill in drill press
4. Line up workpiece and re-drill hole
5. Tap hole
   a. Select tap from (STI) table
   b. Use lubricant, if necessary
   c. Clean out tapped hole
6. Install insert (select from chart specifications)
7. Check fit of insert against blueprint specifications
   a. Accept workpiece, or
   b. Reject workpiece

LEARNING ACTIVITIES

1. Explain the use and theory of operation of thread cutting and helicoils.
2. Demonstrate the use of tap drill and taps.
3. Let students demonstrate and explain the use of thread cutting and taps.
4. Let students select and explain the use of correct tap drill size.
5. Discuss reading assignment.
6. Assign projects for skill development, i.e., supply students with stripped or simulated stripped threaded hole workpiece. Let students install helical coil insert.

RESOURCES

Walker. **Machining Fundamentals,** pp. 490-491.
Helical Coil Wire Screw Thread Insert Table
Crouse. **The Auto Book,** p. 42.

PERFORMANCE OBJECTIVE V-TECS 39 continued

EVALUATION

Written Question

What is the main purpose of helical coil inserts?

Answer

To restore stripped threads to original standard.

DUTY: **PERFORMING BENCHWORK**

TASK: Inspect and change drive pulleys and belts

PERFORMANCE OBJECTIVE V-TECS 37

STANDARD: Drive pulley or belt inspected and changed as required according to repair or maintenance manual standards.

SOURCE OF STANDARD: Oberg, et. al. **Machinery's Handbook,** 21st ed., pp. 1043, 1050.

CONDITIONS FOR PERFORMANCE OF TASK:
Assortment of pulleys and belts
Wrenches
Pulley puller
Measuring instruments
Machinist's handbook
Maintenance or repair manual
Hand tools

PERFORMANCE GUIDE

1. Cut off equipment electrical power
2. Release belt tension
3. Inspect belt for dryness, oil saturation, wear, looseness
4. Determine if belt needs replacement
5. Select replacement belt
   a. Select type (flat/Vee: A or B)
   b. Measure belt for replacement
   c. Select new belt
   d. Splice or lace new belt
6. Inspect pulley for wear, cracks, replacement
7. Remove and replace pulley
   a. Select type (Flat/Vee: A or B)
   b. Measure for replacement
   c. Remove pulley -- check key and/or set-screw
   d. Select new pulley
   e. Place new pulley on shaft
   f. Align pulley to shaft -- check key and/or set-screw
8. Install original or new belt
   a. Align shafting and pulleys
   b. Mount belt
   c. Adjust belt tension according to manual

LEARNING ACTIVITIES

1. Explain use of repair manual specifications.
2. Demonstrate the use of pulley puller.
3. Let students demonstrate how to determine specifications.
4. Let students demonstrate and explain the use of pulleys and safety precautions.
5. Discuss reading assignments.

RESOURCES

Crouse. **The Auto Book**, p. 353.

EVALUATION

Written Question

Give at least one reason for not removing a pulley by hitting with hammer.

Answer

Hitting with hammer will cause pulley to warp, crack, or break.

DUTY: PERFORMING BENCHWORK

TASK: Hone workpiece

PERFORMANCE OBJECTIVE V-TECS 36

STANDARD: The honed workpece must be within a tolerance of between 0.0003" and 0.0005" in roundness and straightness and/or meet blueprint specifications.

SOURCE OF STANDARD: Oberg, et. al. **Machinery's Handbook,** 21st ed., p. 2044.

CONDITIONS FOR PERFORMANCE OF TASK:

Honing machine
Hones
Work-holding device
Precision measuring instruments
Machinist's handbook
Workpiece
Blueprint

PERFORMANCE GUIDE

1. Mount workpiece in work-holding device
2. Select hones
   a. Check drawing specifications for finish
   b. Check drawing specifications for size
   c. Check drawing specifications for material
3. Mount hones on honing machine
4. Calculate honing speeds from machinist's handbook
5. Hone workpiece
6. Check finish and shape of hole
7. Adjust according to table, if necessary
8. Check finish and size of hole
9. Continue steps 5-8 until honing completed
10. Verify workpiece dimensions as within or without specified tolerances
    a. Accept workpiece, or
    b. Reject workpiece and/or take corrective action

LEARNING ACTIVITIES

1. Explain the use of hones and calculating speeds of hones.
2. Demonstrate the use of hones.
3. Demonstrate and explain how to mount hones.
4. Let students demonstrate and explain use of hones.
5. Discuss reading assignment.

RESOURCES

Walker. **Machining Fundamentals,** p. 116.
Krar, et. al. **Technology of Machine Tools,** pp. 77-79.
Crouse. **The Auto Book,** p. 393.

PERFORMANCE OBJECTIVE V-TECS 36 continued

EVALUATION

Written Question
How can operators prevent honing too much or cause tapering?

Answer
Check size often with bore gage or other appropriate measuring tool.

DUTY: PERFORMING BENCHWORK

TASK: Hand whet cutting tools

PERFORMANCE OBJECTIVE V-TECS 35

STANDARD: The cutting tools hand sharpened to job specifications.

SOURCE OF STANDARD: Olivo. **Basic Machine Technology**, pp. 335, 337

CONDITIONS FOR PERFORMANCE OF TASK:
- Oilstones (hones)
- Slip stones
- Lubricant
- Job specifications

PERFORMANCE GUIDE

1. Select oilstone
2. Hone one face of cutting edge
    - a. Use medium/fine abrasive stone
    - b. Apply lubricant
    - c. Hold face flat on surface of oilstone
    - d. Slide stone across face of tool back and forth
    - e. Finish surface on fine abrasive side
3. Repeat steps 1 and 2 on other tool face until job specifications are met

LEARNING ACTIVITIES

1. Explain the use of whet stones.
2. Demonstrate the use of whet stones.
3. Demonstrate and explain angles the tools are to be held and problems resulting from incorrect positioning.
4. Let students demonstrate and explain the use of whet stone and sharpening.
5. Discuss reading assignment.

RESOURCES

Krar, et. al. **Technology of Machine Tools**, pp. 56, 64.
Lascoe, et. al. **Machine Shop Operations and Setups**, p. 76.

EVALUATION

Written Question
Why must oil or water be applied to whet stone during sharpening?

Answer
To keep metal particles from clogging abrasive of which whet stone is made.

DUTY: **PERFORMING BENCHWORK**

TASK: Assemble or disassemble work with arbor press

PERFORMANCE OBJECTIVE V-TECS 27

STANDARD: Set up, remove and replace parts with press to a tolerance of ± 1/64".

SOURCE OF STANDARD: Heineman and Genevro. **Machine Tools Processes and Applications,** p. 15.
Kibbe, et. al. **Machine Tool Practices,** p. 32.

CONDITIONS FOR PERFORMANCE OF TASK:
Arbor press
Clamps
Steel rule
Blueprint
Workpiece

PERFORMANCE GUIDE

1. Perform set up
   a. Take and record measurement of position of part to be removed
   b. Place and clamp stationary part to table
   c. Align moveable part in accordance to ram
2. Remove part
   a. Lubricate both part(s)
   b. Check disassembly procedures
   c. Check for keys, set screws and tapers or shoulders
   d. Apply pressure to remove part (if gages are available, check pressure of operation)
   e. Remove part(s)
3. Replace part(s)
   a. Lubricate both parts
   b. Check disassembly procedures
   c. Align keyways or matching parts
   d. Apply lubricants to all parts
   e. Press parts together
   f. Check tolerance as measured in Step 1
   g. Approve assembly, or
   h. Disapprove assembly and/or take corrective action

LEARNING ACTIVITIES

1. Explain use and theory of operation of arbor press.
2. Demonstrate the use of arbor press.
3. Let students demonstrate and explain the use of arbor press.
4. Let students demonstrate and explain the blueprint specifications relating to the arbor press.
5. Assign projects for skill development, i.e., mount a workpiece with machined hole on a plain mandrel in preparation for turning.

PERFORMANCE OBJECTIVE V-TECS 27 continued

RESOURCES

Walker. **Machining Fundamentals**, p. 196.
Crouse. **The Auto Book**, p. 42.

EVALUATION

Written Question

Explain the basic operation of the arbor press.

Answer

The arbor press uses the mechanical advantage of a rack and pinion to multiply the leverage applied.

DRILL PRESSES

DUTY: OPERATING DRILL PRESSES

TASK: Clean and lubricate drill press

PERFORMANCE OBJECTIVE V-TECS 69

STANDARD: The drill press must be cleaned and lubricated according to service manual specifications.

SOURCE OF STANDARD: Kentucky Writing Team, Incumbent Workers and Instructors

CONDITIONS FOR PERFORMANCE OF TASK:
Furnished with drill press
Brush
Lubricating oil
Cleaning rags
Cleaning solution
Service manual

PERFORMANCE GUIDE

1. Shut off power
2. Clean drill press
   a. Brush off all chips
   b. Wash grease and oil off machine surfaces
   c. Deburr table and column, if necessary
3. Lubricate drill press according to service manual
   a. Coat column and table lightly with oil
   b. Apply grease to fittings
   c. Apply oil to oil cups
   d. Apply oil to sliding parts

LEARNING ACTIVITIES

1. Demonstrate how to turn off power to the machine.
2. Explain the importance of keeping the machine cleaned.
3. Identify the parts to the drill press which must be cleaned and lubricated.
4. Demonstrate the cleaning and lubricating procedures.
5. Identify the oil sight level indicator and its importance.
6. Describe the solution used to wash grease and oil off machine surfaces.
7. Describe how to determine if the table and column need deburring.

RESOURCES

Service manual for drill press

EVALUATION

Written Questions

1. Why should the surface of the table of the drill press be cleaned?
2. What are some cleaning materials to be used to clean the drill press?

Answers

1. The surface of the drill press should be cleaned to prevent the work from being unlevel.
2. A hair brush and cloth rag should be used to clean the drill press table.

DUTY: OPERATING DRILL PRESSES

TASK: Drill hole to size

PERFORMANCE OBJECTIVE V-TECS 72

STANDARD: Hole must be drilled in workpiece (on the drill press) to blueprint specifications to a tolerance of ± 0.005".

SOURCE OF STANDARD: Oberg, et. al. **Machinery's Handbook.** 21st ed., p. 1669.

CONDITIONS FOR PERFORMANCE OF TASK:

Furnished with workpiece
Blueprint
Drill press
Work-holding device
Clamps
Drills
Machinist's handbook
Combination drill and countersink
Deburring tool
Cutting oil
Micrometer caliper
Small hole gages
Steel rule
Depth micrometer
Lubricant

PERFORMANCE GUIDE

1. Identify workpiece material.
2. Select holding device and accessories.
3. Secure work-holding device and check setup for rigidity.
4. Determine hole size
5. Align workpiece with center drill in chuck
6. Calculate speed
7. Set drill press speed
8. Center drill workpiece
9. Select and mount drill
10. Reset speed
11. Drill to dimensions
    a. Use required lubricant
    b. Slow feed as drill penetrates workpiece
    c. Deburr hole
12. Measure hole
    a. Accept workpiece, or
    b. Reject workpiece and/or take corrective action

LEARNING ACTIVITIES

1. Demonstrate setting up workpiece.
2. Discuss hole size and how to compute to specifications.
3. Explain setting up feed and speed.

4. Demonstrate drilling workpiece.
5. Have students practice drilling holes to specifications.

RESOURCES

Johnson. **General Industrial Machine Shop**, p. 321.

EVALUATION

Written Question

What is the decimal equivalent of the fraction drill 1/2 inch?

Answer

The decimal equivalent of the 1/2 inch drill is .500.

DUTY: **OPERATING DRILL PRESSES**

TASK: Countersink hole to specifications

PERFORMANCE OBJECTIVE V-TECS 71

STANDARD: Hole must be countersunk according to blueprint specifications and/or to a tolerance of ± 0.001" on decimal dimensions and ± 1/64" on fraction dimensions.

SOURCE OF STANDARD: Walker. **Machining Fundamentals**, p. 114.

CONDITIONS FOR PERFORMANCE OF TASK:
Furnished with workpiece
Blueprint
Drill press
Work-holding device and accessories
Center punch
Hammer
Center drill
Cutting oil
Countersink
Precision measuring instruments

PERFORMANCE GUIDE

1. Center punch hole location
2. Secure workpiece in work-holding device
3. Secure center drill in drill chuck and set speed
4. Center work under center drill and clamp
5. Center drill workpiece
6. Select drill and secure in drill chuck
7. Drill hole in workpiece
8. Select countersink and secure in drill press
9. Align countersink to hole
10. Countersink to specifications
    a. Apply cutting oil
    b. Set stop
    c. Set speed
    d. Hold cutter in place at end of cut to obtain full depth of cut
11. Verify dimensions
    a. Accept workpiece, or
    b. Reject workpiece and/or take corrective action

LEARNING ACTIVITIES

1. Demonstrate how to secure workpiece.
2. Select countersink size according to blueprint.
3. Demonstrate oil procedure.
4. Explain how to determine the correct speed.
5. Explain what corrective action may be taken on a rejected workpiece.

RESOURCES

Johnson. **General Industrial Machine Shop**, p. 325.
Felker. **Machine Shop Technology**, p. 114.

EVALUATION

Written Questions

1. What is the purpose of countersinking?
2. What is the angle in degrees between the two cutting edges or the angled edges of the countersink?

Answers

1. The purpose of countersinking a drilled hole is to accommodate the head of a flat head machine screw.
2. The included angle of a counter sink is 82°.

DUTY: OPERATING DRILL PRESSES

TASK: Counterbore hole to specifications

PERFORMANCE OBJECTIVE V-TECS 70

STANDARD: Hole must be counterbored to a tolerance of ± 0.001" on decimal dimensions and ± 1/64" on fraction dimensions and/or within blueprint specifications.

SOURCE OF STANDARD: Walker. **Machining Fundamentals**, p. 115.

CONDITIONS FOR PERFORMANCE OF TASK:
Furnished with blueprint
Drill press
Work-holding device
Clamps
Center punch
Hammer
Center drill
Twist drills
Counterbore and pilot
Cutting oil
Hole gage
Telescoping gage
Depth micrometer
Micrometer calipers

PERFORMANCE GUIDE

1. Center punch hole location
2. Secure workpiece in work-holding device
3. Locate and clamp workpiece to table
4. Center drill workpiece
5. Drill workpiece
6. Select counterbore and secure in drill press
7. Counterbore to specifications
    a. Apply required cutting oil
    b. Set speed
    c. Set drill press stop
    d. Hold cutter in place to complete full cut
8. Verify measurements of counterbore with tolerances
    a. Accept workpiece, or
    b. Reject workpiece and/or take corrective action

LEARNING ACTIVITIES

1. Demonstrate how to secure workpiece.
2. Explain how to locate and clamp workpiece to table.
3. Select counterbore and secure in drill press.
4. Demonstrate how to counterbore to specifications.
5. Have students take blueprints, read specifications, and counterbore the hole.
6. Explain what corrective action may be taken on a rejected workpiece.

PERFORMANCE OBJECTIVE V-TECS 70 continued

RESOURCES

Felker. **Machine Shop Technology**, p. 111.
Johnson. **General Industrial Machine Shop**, p. 324.

EVALUATION

Written Question

What is the purpose of a counterbore?

Answer

A counterbore is used when the head of a bolt needs to be inset the depth of the head.

DUTY: **OPERATING DRILL PRESSES**

TASK: Spotface to specified dimensions

PERFORMANCE OBJECTIVE V-TECS 80

STANDARD: Spotface to a tolerance of ± 0.005" on decimal dimensions, ± 1/64" on fraction dimension and/or blueprint specifications.

SOURCE OF STANDARD: Olivo. **Fundamentals of Machine Technology,** p. 267.
Walker. **Machining Fundamentals,** p. 19.

CONDITIONS FOR PERFORMANCE OF TASK:
Furnished with blueprint
Workpiece
Drill press
Work-holding device
Spotfacing tools
Depth micrometer
Steel rule
Machinist's handbook

PERFORMANCE GUIDE

1. Identify workpiece material
2. Select holding device and accessories
3. Secure work in holding device and check set up for ridigity
4. Select spotface tool and pilot
5. Mount spotfacing tool in drill press
6. Set speed of drill (see handbook)
7. Set stop for depth
8. Align workpiece
9. Start drill press
10. Spotface workpiece
    a. Lubricate
    b. Face to dimensions
11. Measure spotface
12. Re-adjust depth stop and recut spotface, as required to blueprint specifications

LEARNING ACTIVITIES

1. Demonstrate securing work in holding device.
2. Explain aligning workpiece.
3. Select spotface tool and pilot.
4. Explain setting stop for depth.
5. Explain how to compute speed of drill and how to set stop for depth.

RESOURCES

Johnson. **General Industrial Machine Shop,** p. 353.

EVALUATION

Written Question

1. Explain spotfacing.
2. Give list of tools to be used in spotfacing.

Answers

1. Spot facing is the process of making circular flat spots on the face of a workpiece.
2. Tools used in spotfacing operations are: grinding compound, polished metal, drill press and a wood dowel pin.

DUTY: **OPERATING DRILL PRESSES**

TASK: Drill hole with automatic feed

PERFORMANCE OBJECTIVE V-TECS 73

STANDARD: Operations must be according to the performance guide. Workpiece must be within a tolerance of ± 0.001" on decimal dimensions and ± 1/64" on fraction dimensions and/or within blueprint specifications.

SOURCE OF STANDARD: Walker. **Machining Fundamentals,** p. 19.
McCarthy and Smith. **Machine Tool Technology,** p. 179.

CONDITIONS FOR PERFORMANCE OF TASK:
Furnished with blueprint
Workpiece
Drill press with automatic feed
Clamps
Machinist's handbook
Micrometer caliper
Small hole gage
Depth micrometer
Steel rule
Lubricant

PERFORMANCE GUIDE

1. Determine drill press operation.
2. Secure workpiece in work-holding device
3. Secure tools and attachments
4. Align tool to workpiece
5. Determine and set feed
6. Determine and set speed
7. Clamp workpiece to table
8. Drill workpiece
    a. Use lubricant as required
    b. Set required stops
    c. Engage power feed
9. Measure workpiece
    a. Accept workpiece as within specified tolerance, or
    b. Reject workpiece and/or take corrective action

RESOURCES

Johnson. **General Inustrial Machine Shop,** p. 340.

EVALUATION

Written Question
When is the drill press with automatic feed lubricated?

Answer
The drill press with automatic feed should be lubricated each time it is used.

DUTY: OPERATING DRILL PRESSES

TASK: Drill workpiece with drill jigs

PERFORMANCE OBJECTIVE V-TECS 74

STANDARD: Drilled workpiece must be within a tolerance of ± 0.005" on decimal dimension, ± 1/64" on fraction dimensions and/or meet blueprint specifications.

SOURCE OF STANDARD: Walker. **Machining Fundamentals**, pp. 457-459.

CONDITIONS FOR PERFORMANCE OF TASK:
Furnished with workpiece
Blueprint
Drill press
Drill jig
Drills
Drill bushings
Clamps

PERFORMANCE GUIDE

1. Clean and deburr workpiece
2. Place drill bushing in drill jig
3. Clamp workpiece on drill jig
4. Check contact with stops on gages
5. Place drill in chuck
6. Place workpiece and drill jig on drill press table
7. Adjust table to drill
8. Lower drill into drill bushing
9. Clamp jig or secure with stops
10. Adjust speed of drill press
11. Drill hole in workpiece
    a. Use lubricant, if necessary
    b. Raise and lower drill to clean chips
    c. Ease downward pressure on penetration of workpiece
12. Repeat steps 8-11 for other holes same diameter
13. Measure workpiece
    a. Accept workpiece as within specified tolerances, or
    b. Reject workpiece

LEARNING ACTIVITIES

1. Demonstrate cleaning and preparing workpiece.
2. Explain setting drill bushing in drill jig.
3. Discuss setting contact with stops or gages.
4. Describe how to adjust speed of drill press.
5. Explain what corrective action may be taken on a rejected workpiece.

RESOURCES

Johnson. **General Industrial Machine Shop**, p. 335.

PERFORMANCE OBJECTIVE V-TECS 74

EVALUATION

Written Question

1. Give definition of drill jig.
2. Give at least one use of drill jig.

Answers

1. The drill jig is used to hold parts being drilled.
2. A drill jig furnishes a guide for drilling a hole accurately.

DUTY: **OPERATING DRILL PRESSES**

TASK: Lap hole to size

PERFORMANCE OBJECTIVE V-TECS 75

STANDARD: Lapped hole must be within a tolerance of ± 0.001" and/or meet blueprint specifications.

SOURCE OF STANDARD: Oberg, et. al. **Machinery's Handbook,** 21st ed., pp. 2044-2048.

CONDITIONS FOR PERFORMANCE OF TASK:
Furnished with workpiece
Blueprint
Adjustable lap
Abrasives
Lubricant
Work-holding device
Drill press
Hole gage
Micrometer caliper

PERFORMANCE GUIDE

1. Mount workpiece in work-holding device
2. Clean and deburr hole
3. Measure hole, adjust lap over hole size (.002-.003 on 1" diameter)
4. Charge lap
5. Secure lap in drill press
6. Start drill press (slow speed)
7. Run lap in and out of hole with light pressure
8. Add lubricant but not abrasive
9. Clean and measure hole
10. Repeat steps 3-9 until hole size is within tolerance of designated dimensions.

LEARNING ACTIVITIES

1. Demonstrate mounting workpiece in work-holding device.
2. Adjust lap over hole size .002-.003.
3. Explain securring lap in drill press.
4. Demonstrate how to run lap in and out of hole with light pressure.
5. Explain why it is necessary to start drill press at a slow speed.

RESOURCES

Anderson and Tatro. **Shop Theory,** p. 167.

EVALUATION

Written Question
What is meant by lapping a hole to size?

Answer
Lapping a hole to size is a process used to take very small amounts out of a drill hole with use of abrasive.

DUTY: **OPERATING DRILL PRESSES**

TASK: Mount work on V-blocks

PERFORMANCE OBJECTIVE V-TECS 76

STANDARD: Workpiece must be mounted so workpiece can be drilled within a tolerance of ± 1/64" on fraction dimensions.

SOURCE OF STANDARD: Olivo. **Fundamentals of Machine Technology,** pp. 216-217.

CONDITIONS FOR PERFORMANCE OF TASK:
Furnished with round workpiece
Blueprint
Drill press
Clamps
Straps
Matched V-blocks
Drills
Center drill
Combination
Square
Layout dye
Scriber
Center head
Surface gage
Center punch
Hammer

PERFORMANCE GUIDE

1. Clean and deburr workpiece
2. Clean and deburr V-blocks
3. Coat workpiece with layout dye at hole location
4. Measure hole location with square and center punch workpiece
5. Mount workpiece in V-blocks
6. Place assembly on surface plate
7. Locate center punch mark centered on top
8. a. Check from each side with square
   b. Check from each side with surface gage
9. Clamp workpiece in V-blocks
10. Check accuracy of set up
11. Mount assembly on drill press table
12. Place center drill in chuck
13. Locate center punch mark on workpiece under point of center drill
14. Clamp assembly to table
15. Turn on drill press and lightly touch workpiece with center drill to verify set-up
    a. Accept set-up, or
    b. Reject set-up and repeat steps 3-14 until workpiece within specified tolerance

PERFORMANCE OBJECTIVE V-TECS 76 continued

LEARNING ACTIVITIES

1. Demonstrate cleaning work and V-blocks for set up.
2. Demonstrate laying out work piece.
3. Demonstrate mounting assembly on drill press.
4. Explain how to set punch mark on center top.
5. Have students practice mounting workpiece on V-blocks and setup drill to within specified tolerance.

RESOURCES

Felker. **Machine Shop Technology**, p. 93.
Johnson. **General Industrial Machine Shop**, p. 331.

EVALUATION

Written Question

1. What type stock are V-blocks used to hold?
2. When and why are V-blocks used?

Answers

1. V-blocks are designed to hold firm, round stocks.
2. V-blocks are used to hole the work piece firm and in place when setting up to drill the work piece.

DUTY: **OPERATING DRILL PRESSES**

TASK: Ream hole to size

PERFORMANCE OBJECTIVE V-TECS 77

STANDARD: The hole in workpiece must be reamed to drawing specifications to a tolerance of $\frac{+0.0005"}{-0.0000"}$.

SOURCE OF STANDARD: Oberg, et. al. **Machinery's Handbook.** 21st ed., p. 1646.

CONDITIONS FOR PERFORMANCE OF TASK:
Furnished with blueprint
Workpiece
Drill press
Work-holding device
Center drill
Drills
Reamers
Cutting oil
Vernier micrometer caliper
Hole gage

PERFORMANCE GUIDE

1. Identify workpiece material
2. Set drill press speed for drilling
3. Select holding device and accessories
4. Secure work in holding device
5. Align workpiece and center drill and clamp holding device
6. Check rigidity of set up
7. Center drill workpiece (lubricate, as required)
8. Select drill and drill workpiece to dimensions (lubricate, as required)
   a. Drill undersize for reaming allowance
   b. Check sharpness of drill
9. Select reamer
10. Change drill press speed to one half drilling speed
11. Ream hole
    a. Mount reamer in drill press (in chuck or spindle)
    b. Use lubricant as required
    c. Feed through workpiece
    d. Clean and deburr hole
12. Measure hole
    a. Accept workpiece as within specified tolerance, or
    b. Reject workpiece

LEARNING ACTIVITIES

1. Compute and discuss drill press speed for reaming.
2. Select proper holding-device.
3. Explain rigidity.
4. Select the right drill size.
5. Demonstrate mounting and using of reamer.

RESOURCES

Felker. **Machine Shop Technology**, p. 104.
Johnson. **General Industrial Machine Shop**, p. 355.

EVALUATION

Written Question

1. Define reaming.
2. How do you tell the difference between a hand reamer and a power reamer?
3. How are reamers classified?

Answers

1. Reaming is the process of making drilled holes smooth and accurate.
2. Hand reaming is done by hand and on a bench.
   Power reaming may be performed on a drill press, lathe, turret lathe, or on milling machine.
3. Reamers are classified as hand reamers and power reamers.

DUTY: OPERATING DRILL PRESSES

TASK: Sharpen drill free hand

PERFORMANCE OBJECTIVE V-TECS 78

STANDARD: The drill must be sharpened so it will drill a hole to a tolerance of ± 0.005".

SOURCE OF STANDARD: Oberg, et. al. **Machinery's Handbook.** 21st ed., p. 1669.
Olivo. **Fundamentals of Machine Technology,** pp. 235-236.

CONDITIONS FOR PERFORMANCE OF TASK:
Furnished with bench
Grinder
Drills
Drill point gage
Reference handbook
Wheel dresser
Work-holding device
Drill press

PERFORMANCE GUIDE

1. Observe safety practices.
2. Inspect drill
3. Dress and true grinding wheel
4. Locate workrest horizontal and within 1/8" of wheel
5. Turn on grinder
6. Sharpen drill
   a. Hold drill with one hand on workrest at 59° angle to wheel face
   b. Use forefinger as positioner
   c. Hold shank with other hand
   d. Apply pressure against wheel moving shank end down in an arc motion
   e. Check angle against drill point gage
   f. Follow steps a-e on other cutting edge of drill
   g. Check drill for length of cutting edge, angle, and clearance
   h. Repeat steps a-g, alternating cutting edges until drill meets specifications
7. Mount workpiece in work-holding device and drill test hole
8. Measure hole
   a. Accept sharpened drill as within specified tolerance, or
   b. Reject drill and repeat steps 6-7 until sharpened drill meets specifications

LEARNING ACTIVITIES

1. Discuss safety practices.
2. Demonstrate how to dress and true grinding wheel.
3. Explain method to hold drill while sharpening.
4. Check angle of lip of drill to grinding wheel face.
5. Demonstrate how to sharpen drill free hand.

PERFORMANCE OBJECTIVE V-TECS 78 continued

RESOURCES

Felker. **Machine Shop Technology,** pp. 87-89.
Johnson. **General Industrial Machine Shop,** p. 327.

EVALUTION

Written Question

1. Why should cutting edges of the drills be equal in length?
2. Why is it necessary to thin the web on some drills?
3. Why should cutting edges of the drill be the same angles?

Answers

1. If the cutting edges were different in length the size of the hole would vary.
2. As the drills get small the webb gets thicker. This means the point would be hard to fit in a center punch mark.
3. If the cutting edges differ in the angle with the center point of the drill, this would make the drill chip or break.

DUTY: **OPERATING DRILL PRESSES**

TASK: Sharpen drill with grinding attachment

PERFORANCE OBJECTIVE V-TECS 79

STANDARD: Sharpened drill must fit gage and drill a hole to a tolerance of ± 0.005".

SOURCE OF STANDARD: Delmar. **Milling Machine Work**, p. 1559.

CONDITIONS FOR PERFORMANCE OF TASK:
Furnished with grinder
Drills
Drill sharpening manual
Drill point gage
Drill press
Work-holding device
Drill grinding attachments
Reference handbook
Micrometer
Hole gage

PERFORMANCE GUIDE

1. Dress and true grinding wheel (wear goggles)
2. Follow manufacturer's manual to operate drill grinding fixture
3. Grind lip clearance, length, and angle to specifications.
4. Check drill with drill point gage
5. Regrind alternately each cutting edge until drill fits drill point gage
6. Mount workpiece in work-holding device
7. Drill hole in workpiece with sharpened drill
8. Measure drilled hole
    a. Accept sharpened drill as within specifications, or
    b. Repeat steps 2-8 until drill meets specifications

LEARNING ACTIVITIES

1. Demonstrate how to dress and true grinding rock.
2. Explain how to mount drill in grind grinding attachment.
3. Discuss process in sharpening drill.
4. Explain checking drill with drill point gage.
5. Discuss safety procedures.

RESOURCES

Johnson. **General Industrial Machine Shop**, p. 327.
Felker. **Machine Shop Technology**, pp. 89-91.

EVALUATION

Written Questions

1. Name two methods of grinding twist drills.
2. How do you check the amount of lip clearance when sharpening drill with grinding attachment?

Answers

1. Twist drills can be sharpened by free hand grinding or by a drill pointing machine.
2. A drill grinding gage can be used to check lip clearance on drills.

DUTY: OPERATING DRILL PRESSES

TASK: Tap hole by hand on drill press

PERFORMANCE OBJECTIVE V-TECS 81

STANDARD: The hole must be hand tapped on drill press to blueprint specifications to a tolerance of 1/64" on fraction dimensions and to fit a GO NO-GO gage.

SOURCE OF STANDARD: Walker. **Machining Fundamentals,** p. 19.
Oberg, et. al. **Machinery's Handbook,** 21st ed., p. 1918.

CONDITIONS FOR PERFORMANCE OF TASK:
Furnished with workpiece
Blueprint
Drill press
Tap drills
Taps
Drill chuck and key
Drill press vise
Dead center
Combination drill and countersink
Machinist's handbook
Lubricant
GO NO-GO thread plug gage

PERFORMANCE GUIDE

1. Select tap drill and tap as specified on blueprint (refer to machinist's handbook)
2. Mount workpiece in drill press vise
3. Mount drill press vise on drill press table
4. Mount and align combination drill and countersink to workpiece
5. Select and set drill press speed
6. Set depth stop on drill press
7. Center drill workpiece
8. Drill workpiece with tap drill
9. Mount tap in tap wrench and align to drilled hole
10. Mount dead center in drill chuck and align to tap center
11. Hand tap hole to specifications using lubricant
12. Check tapped hole with GO NO-GO thread plug gage after cleaning chips out of hole
    a. Accept workpiece as within tolerances, or
    b. Reject workpiece

LEARNING ACTIVITIES

1. Explain how work is mounted to be drilled.
2. Select tap drill and tap as specified.
3. Demonstrate setting drill press speed.
4. Demonstrate drilling workpiece with tap drill.
5. Demonstrate hand tapping on workpiece.

RESOURCES

Felker. **Machine Shop Technology**, pp. 37-38.
Johnson. **General Industrial Machine Shop**, pp. 196-197.

EVALUATION

Written Questions

1. Give the names of two tools used for hand tapping.
2. What is hand tapping?
3. What are the names of the three taps of a set?
4. What is a tap drill?

Answers

1. The "T" tap wrench and the tap handle are tools used when tapping holes.
2. Hand tapping is the process of cutting thread internally.
3. The three taps of a set are: taper, plug, bottoming.
4. The tap drill is a drill used to create a hole that is to be tapped.

DUTY: **OPERATING DRILL PRESSES**

TASK: Tap hole with tapping attachment

PERFORMANCE OBJECTIVE V-TECS 82

SOURCE OF STANDARD: Oberg, et. al. **Machinery's Handbook**, 21st ed., p. 1918.

CONDITIONS FOR PERFORMANCE OF TASK:
Furnished with workpiece
Blueprint
Drill press
Work-holding device
Tapping attachment
Operator's manual
Drills
Taps
GO NO-GO gages
Combination drill and countersink
Cutting oil

PERFORMANCE GUIDE

1. Mount workpiece in work-holding device
2. Select tap drill and tap
3. Mount center drill in drill press
4. Secure workpiece to drill press table aligned with center drill
5. Set speed and feed
6. Center drill, then drill hole
7. Mount and secure tapping attachment
8. Tap hole to specifications
   a. Mount tap in collet
   b. Check operator's manual for tapping attachment operation
   c. Set drill press speed
   d. Set drill press stop when required
   e. Allow tap to complete cut to full depth before retracting from hole
9. Clean tapped hole and check with GO NO-GO gage
   a. Accept workpiece as within specifications, or
   b. Reject workpiece

LEARNING ACTIVITIES

1. Explain procedure in selecting the right drill for a certain tap.
2. Demonstrate feed and speed.
3. Demonstrate tapping attachment.
4. Discuss tapping hole to specifications.
5. Select tap and tap drill.

PERFORMANCE OBJECTIVE V-TECS 82 continued

RESOURCES

Johnson. **General Industrial Machine Shop**, p. 201.

EVALUATION

Written Questions

1. What is the correct tap drill for a 3/8 - 16 tap?
2. In what direction does the tap turn?

Answers

1. The 3/8 - 16 threads per inch tap drill is a 5/16 inch drill.
2. All right hand taps turn to the right or clockwise.

GRINDERS

DUTY: OPERATING GRINDERS

TASK: Clean and lubricate grinders

PERFORMANCE OBJECTIVE V-TECS 85

STANDARD: Grinder must be clean and lubricated according to manufacturer's specifications.

SOURCE OF STANDARD: Kentucky Writing Team, Incumbent Workers and Instructors.
Oberg, et. al. **Machinery's Handbook**, p. 2012.

CONDITIONS FOR PERFORMANCE OF TASK:
Furnished with grinder
Machinist's handbook
Manufacturer's specifications
Cleaner
Rags
Brush
Lubricant
Wrenches
Hand tools

PERFORMANCE GUIDE

1. Obtain manufacturer's specifications for grinder
2. Turn power off
3. Clean grinder
   a. Remove chips with brush
   b. Clean machine with cleaner and rags
4. Lubricate grinder according to manufacturer's specifications
   a. Place oil in oil cups
   b. Place grease in grease fittings
   c. Oil slides and machine surfaces lightly
5. Remove grinding wheel
   a. Ring test for cracks
   b. Caution: Replace wheel if cracked
   c. Check blotters and flanges
6. Replace wheel and check wheel cover and guards
7. Check exhast system
8. Inspect grinder
   a. Accept grinder as cleaned and lubricated according to manufacturer's specifications, or
   b. Reject grinder and take corrective action

LEARNING ACTIVITIES

1. Explain use of manufacturer's handbook or charts attached to machine.
2. Remind students that cleaning with brush and rag is safer for machine and worker.
3. Demonstrate and/or explain use of oils and grease in proper place and sufficient amounts.
4. Remind trainees to check wheel covers and guard for cracks.
5. Assign appropriate projects for skill development, i.e., have students clean and lubricate grinders weekly or after 8-10 hours of operation.

PERFORMANCE OBJECTIVE V-TECS 85 continued

RESOURCES

Oberg, et. al. Machinery's Handbook, p. 2012.

EVALUATION

Written Questions

1. Why should air hose not be used to clean machine?
2. If a little grease is good for machine, why wouldn't a large amount be better?

Answers

1. Air pressure may force grit into bearings and blow grit in worker's eyes.
2. Excess grease may short out electrical motors and bearing surface can only hold a certain amount; excess is wasted.

DUTY: OPERATING GRINDERS

TASK: Balance grinding wheel

PERFORMANCE OBJECTIVE V-TECS 83

STANDARD: Grinding wheel must be balanced to manufacturer's specifications.

SOURCE OF STANDARD: Krar and Oswald. **Grinding Technology**, pp. 73-74.

CONDITIONS FOR PERFORMANCE OF TASK:
Furnished with grinding wheel
Balance arbor
Balance stand
Wheel collet
Grinder
Diamond dresser
Balance weights
Wrenches
Chalk

PERFORMANCE GUIDE

1. Assemble grinding wheel to wheel collet (ring test wheel and replace cracked wheel)
2. Mount assembly on grinding machine and remove balance weights
3. Roughly true wheel with diamond dresser
4. Run grinding wheel several minutes to equalize coolant in wheel
5. Remove assembly and insert balance arbor
6. Place this assembly on balance stand
    a. Balance stand must be level
    b. Allow wheel to roll until heavy side is down
7. Mark heavy side with chalk and draw horizontal line through wheel axis
8. Insert two balancing weights on centerline
9. Move weights above centerline away from the chalk mark
    a. Move weights equally
    b. Tighten in position
10. Rotate wheel 90°
11. Adjust weights until wheel remains in this position
12. Rotate wheel 180°
13. Check for rotation by locating chalk mark in different positions
    a. Accept wheel as balanced if it does not rotate, or
    b. Reject wheel which does rotate and repeat steps 10-13 until wheel is balanced

LEARNING ACTIVITIES

1. Explain use and/or theory of balancing grinding wheel.
2. Demonstrate the ring test to determine cracked wheels.
3. Demonstrate and/or explain use of truing with diamond dresser.
4. Demonstrate and/or explain use of weights and chalk marks.
5. Demonstrate wheel balancing without interruption.

RESOURCES

Krar, et. al. **Technology of Machine Tools**, pp. 340-341.

EVALUATION

Written Questions

1. Why is the proper balance of a grinding wheel essential?
2. Describe briefly the procedure for balancing a grinding wheel.

Answers

1. To eliminate vibration and chatter.
2. a. Mount wheel and adaptor on surface grinder and true wheel.
   b. Remove wheel and mount on tapered arbor and place on balancing stand.
   c. Allow wheel to rotate until it stops, mark heavy point with chalk.
   d. Loosen balancing wheel weights and move to point opposite chalk mark.
   e. Repeat until balanced.

DUTY: OPERATING GRINDERS

TASK: Dress and true grinding wheels on pedestal grinder

PERFORMANCE OBJECTIVE V-TECS 87

STANDARD: Grinding wheel must have grains and metal particles removed and be concentric and the face flat within a tolerance of ± 1/64".

SOURCE OF STANDARD: Oberg, et. al. **Machinery's Handbook,** pp. 1998-2004.
Olivo. **Fundamentals of Machine Technology,** p. 197.

CONDITIONS FOR PERFORMANCE OF TASK:
Furnished with grinder
Reference material
Sharpening tools
Pedestal grinder
Grinding wheel
Mechanical wheel dresser
Wrenches
Machinist's handbook

PERFORMANCE GUIDE

1. Check wheel for cracks
   (Caution: replace cracked wheel)
2. Adjust spark guard within 1/64" of wheel
3. Select wheel dresser
   a. Check dresser discs or cutters
   b. Check reference material for type to use
4. Adjust work rest to allow lugs of dresser to ride on front of work rest and cutters almost touch wheel
5. Adjust safety sheld and wear goggles
6. Start grinder (stand to one side when starting)
7. Place dresser lugs against front edge of work rest (no contact with wheel)
8. Hold dresser down on work rest and move across face of wheel
   a. Tilt dresser upwards slightly
   b. Raise slightly after each pass
9. Check sharpness of wheel
10. Continue passes until wheel is dressed and trued
    (Caution: adjust work rest within 1/8" or less of wheel)

LEARNING ACTIVITIES

1. Explain use and/or theory of operation of mechanical wheel dresser.
2. Demonstrate the use of ring test and adjustment of spark guard to proper distance.
3. Demonstrate adjustment of work rest to fit lugs of dresser.
4. Demonstrate use of dresser by contacting face of wheel and proper movement until wheel is true and sharp.
5. Assign appropriate projects for skill development, i.e., let students demonstrate dressing grinding wheel.

PERFORMANCE OBJECTIVE V-TECS 87 continued

RESOURCES

Krar, et. al. Technology of Machine Tools, pp. 321, 341-342, 348, 351.

EVALUATION

Written Question

1. Explain ring test.
2. Give two reasons for dressing and truing.

Answers

1. Vitrified or silicate wheel will give a metallic ring sound if they are sound; cracked wheel will not ring.
2. a. Dressing makes wheel cut better by exposing sharp abrasive particles.
   b. Wheel will grind with maximum surface contact without vibration.

DUTY: OPERATING GRINDERS

TASK: Grind and shape chisels and hand tools on pedestal grinder

PERFORMANCE OBJECTIVE V-TECS 89

STANDARD: Ground tools must be within a tolerance of ± 3° on angular dimensions and ± 1/64" on fraction dimensions.

SOURCE OF STANDARD: Kentucky Writing Team, Incumbent Workers and Instructors.
Olivo. **Fundamentals of Machine Technology,** pp. 198-199.

CONDITIONS FOR PERFORMANCE OF TASK:
Furnished with grinder
Specifications
Hand tools
Pedestal grinder
Drills
Punches
Screwdrivers
Wheel dresser
Protractor
Steel rule

PERFORMANCE GUIDE

1. Inspect grinding wheel and replace cracked wheel
2. Dress, if required (caution: wear goggles)
3. Adjust work rest within 1/16" of wheel
4. See that guards are in place
5. Start grinder
6. Grind tool
   a. Grind flat surface
      1. Hold tool at right angles to wheel face
      2. Hold down on work rest with one hand
      3. Guide tool across wheel with other hand
      4. Move tool across face of wheel
      5. Continue cuts until tool face ground square
      6. Finish grind on fine wheel
   b. Grind angular surfaces
      1. Set work rest at or near required angle and within 1/8" of wheel face
      2. Hold tool on work rest with one hand
      3. Start grinder
      4. Move tool with other hand across wheel face
      5. Check angle with protractor
      6. Adjust work rest as required
      7. Grind tool following steps 2-7 until tool ground within tolerance
   c. Grind point
      1. With one hand hold tool against work rest at required angle
         a. Included angle of center punch is 90°
         b. Included angle of prick punch is 30°

        2. Bring tool against wheel with other hand
            a. Rotate tool with fingers
            b. Move tool across face of wheel
        3. Check angle with protractor
        4. Change angle if necessary and grind until tool is required angle
7. Inspect and measure tool
    a. Accept tool, or
    b. Reject tool and/or take corrective action

LEARNING ACTIVITIES

1. Explain use of protractor and measuring tool to determine angles to be ground on chisels.
2. Demonstrate holding tool against work rest using one hand and using other hand to manipulate tool being ground.
3. Demonstrate grinding points on punches.
4. Discuss reading assignments concerning angles and/or specification of tool sharpening.
5. Assign appropriate projects for skill development, i.e., issue dull or damaged tools to be reconditioned.

RESOURCES

Walker. **Machining Fundamentals**, p. 70.
Krar, et. al. **Technology of Machine Tools**, p. 68.

EVALUATION

Written Question

How may angles and bevels be determined on chisels and punches?

Answer

Use vernier protractor or protractor head on combination set.

DUTY: **OPERATING GRINDERS**

TASK: Grind and sharpen lathe tools free hand

PERFORMANCE OBJECTIVE V-TECS 90

STANDARD: Tools must be within ± 2° of angles on tool angle gage.

SOURCE OF STANDARD: Krar, et. al. **Technology of Machine Tools**, pp. 154-155.

CONDITIONS FOR PERFORMANCE OF TASK:

Furnished with blueprint
Workpiece
References
Lathe tool kit
Pedestal grinder
Wheel dresser
Tool angle gage
Protractor
Oilstone
Lubricate
Machinist's handbook

PERFORMANCE GUIDE

1. Check references for side cutting edge angle and side relief angle required for tool bit
2. Adjust work rest within 1/16" of wheel face.
3. Sharpen and dress grinding wheel (Caution: wear goggles)
4. Grip one end of tool with both hands and rest left hand on work rest
5. Hold tool at approximate cutting edge angle and tilt tool to approximate relief angle
6. Hold tool against grinding wheel and move across face of wheel
7. Move tool back and forth across wheel
8. Check relief angle of toolbit in toolholder with tool angle gage
9. Correct for any error when positioning toolbit against grinding wheel
10. Grind until relief angle fits tool angle gage and is approximately 1/2" long for a 1/4" toolbit
11. Check end relief angle required
12. Grind and relief angle so it forms a 70° angle with side cutting edge (grind end cutting edge angle and end relief angle at same time)
13. Check end relief angle (with tool in toolholder) against tool angle gage
14. Grind and check end relief angle until it fits gage
15. Check side rake angle required
16. Hold top of tool approximately 45° to axis of wheel and grind side rake.
17. Grind slight radius on point of tool maintaining front and side clearance angles of finished tool
18. Whet cutting edges on oilstone using lubricant
19. Verify angles of tool with protactor and/or tool gage
    a. Accept tool as within specified tolerance, or
    b. Reject tool and regrind to specifications

LEARNING ACTIVITIES

1. Explain use and/or theory of lathe tool geometry (6 angles to be ground).
2. Demonstrate the use of angle gages and protractor.
3. Demonstrate and/or explain use of reflief angles, cutting edge angles and rake angles.
4. Let students demonstrate and/or explain use of relief angles, cutting edge angles and rake angles.
5. Discuss reading assignments.
6. a. Have enlarge samples made of wood or light weight materials to serve as guides.
   b. Let students practice on short pieces of square CRS key stock.
   c. Let students sharpen dull bits or grind new bits to be used in lathe work at later time.

RESOURCES

Walker. **Machining Fundamentals**, pp. 146-148.
Krar, et. al. **Technology of Machine Tools**, pp. 152-155.

EVALUATION

Written Questions

1. Name six angles to be ground on high speed lathe bit.
2. Why should bit be cooled in water while grinding?

Answers

1. Side cutting edge angle, end cutting edge angle, end relief angle, side relief angle, back rake angle, side rake angle
2. To prevent overheating which may remove temper.

DUTY: OPERATING GRINDERS

TASK: Dress and true machine tool grinding wheel

PERFORMANCE OBJECTIVE V-TECS 88

STANDARD: Grinding wheel must be dressed in accordance with blueprint specifications.

SOURCE OF STANDARD: Krar and Oswald. **Grinding Technology**, pp. 77, 81.

CONDITIONS FOR PERFORMANCE OF TASK:
Furnished with grinder
Blueprint
Dressing tools
Surface grinder
Grinding wheel
Diamond point dresser
Fixed tool post
Magnetic chuck

PERFORMANCE GUIDE

1. Ring test wheel for cracks (Caution: replace cracked wheel)
2. Select diamond point dresser
    a. Single point or multiple point
    b. Rotate diamond if worn
3. Place truing tool in tool post or attachment
4. Position diamond point dresser on magnetic chuck
    a. Clean magnetic chuck
    b. Position slightly to left of wheel centerline
    c. Angle dresser about 10° to left (direction of wheel rotation)
    d. Place a piece of paper under left end of dresser holder
5. Raise wheel above height of diamond
6. Adjust table laterally to position under high point of wheel
7. Start grinder (Caution: wear goggles)
8. Carefully lower wheel until it just touches diamond
9. Feed diamond across wheel with crossfeed handle
    a. Use medium feed for general purpose grinding
    b. Use fast feed for fast metal removal
    c. Use slow feed for slow metal removal but good finish
10. Lower wheel 0.0005" for each pass until wheel is dressed to specifications

LEARNING ACTIVITIES

1. Explain use and/or theory of operation of diamond wheel dressers.
2. Demonstrate the selection of wheel dresser and mounting dresser in holder
3. Demonstrate and/or explain cleaning chuck, position of dresser in relation to wheel and angle of dresser.
4. Demonstrate use of dresser by touching off and feeding across lowering wheel .0005" each pass.
5. Caution students to wear goggles, stay to one side when starting grinder, to use steady motions, and to check frequently to prevent excessive dressing.

PERFORMANCE OBJECTIVE V-TECS 88 continued

RESOURCES

Krar, et. al. **Technology of Machine Tools**, p. 341.

EVALUATION

Written Questions

1. Define dressing.
2. Define truing.

Answers

1. The operation of removing the dull grains and metal particles from grinder wheel with wheel dresser.
2. Truing a wheel is the operation of removing high spots on wheel to make it concentric to spindle.

DUTY: OPEATING GRINDERS

TASK: Grind workpiece square on surface grinder

PERFORMANCE OBJECTIVE V-TECS 99

STANDARD: The four sides must be squared to a tolerance of ± 30 minutes, and to a tolerance of ± 0.002" on decimal dimension, ± 1/64" on fraction dimensions, and/or to blueprint specifications.

SOURCE OF STANDARD: Olivo. **Basic Machine Technology**, p. 15.

CONDITIONS FOR PERFORMANCE OF TASK:

- Surface grinder with magnetic chuck
- 90° angle plates
- C clamps
- Diamond dresser
- Outside micrometer
- Vernier bevel protractor
- Solid steel square
- Steel rule
- Rough workpiece
- Blueprint

PERFORMANCE GUIDE

1. Select, inspect and install wheel on surface grinder
2. Replace all guards before starting grinder
   CAUTIONS: Always wear eye protection
   Keep hands clear of running wheel
   Turn magnet on before using wheel
   Use guards around wheel
3. Place diamond dresser on chuck and dress wheel (wear goggles)
4. Clean chuck and place workpiece on it making sure that space between wheel and chuck is sufficient to clear workpiece
5. Carefully lower wheel until it just touches workpiece at its highest point
6. Move workpiece out of path of wheel and lower wheel for desired cut
7. Start flow of coolant, if necessary, and complete cut
8. Grind until first surface is "cleaned up." (Care should be taken here to make sure enough material is left to allow opposite side to be finished and still hold required size)
9. Grind second surface at 90° angle at first; clean chuck and place angle plate on it; secure first surface of workpiece to vertical surface of angle plate holding it with C clamps; make sure that workpiece is higher than top of angle plate or any part of C clamp, then proceed as in steps 5-8 from above
10. To finish surface #3, clean chuck and place workpiece on it with surface #1 down, and repeat steps 4 and 5 until required dimension is reached
11. To finish surface #4, repeat step 10 with surface #2 down
12. Measure workpiece
    a. Accept workpiece, or
    b. Reject workpiece and/or take corrective action

LEARNING ACTIVITIES

1. Explain selection, inspection, and installation of wheel, and remind students to follow safety rules.
2. Demonstrate the grinding of first surface until it is "cleaned up."
3. Demonstrate grinding second surface 90° to first one. (Clean chuck)
4. Demonstrate grinding surface #3 by placing surface #1 down in contact with chuck.
5. Continue demonstration by placing surface #2 down on chuck and grind last surface (#4).
6. Demonstrate using a steel square to check for squareness. Measure with micrometer and protractor to ensure blueprint tolerance.

RESOURCES

Walker. **Machining Fundamentals,** p. 292.
Krar, et. al. **Technology of Machine Tools,** p. 346.

EVALUATION

Written Questions

1. Give three safety precautions when using surface grinders.
2. Give steps in grinding workpiece square on surface grinders.

Answers

1. a. Always wear safety glasses
   b. Ring test wheel before mounting
   c. When starting grind, stand to one side and make sure no one is in line with grinding wheel in case of breakage.
2. a. Mount workpiece properly on magnetic chuck
   b. Set table traverse dogs to allow 1/2 inch more clearance on each end of table travel
   c. Lower wheel head to work until it sparks on highest point of workpiece
   d. Grind flat by lowering wheel-head .0005 to .001 each cut
   e. When first surface is flat, grind opposite surface
   f. Grind third surface flat; then check with precision square
   g. Make adjustment if necessary using shims
   h. Grind opposite (4th side) side
   i. Accept, reject or rework until square

DUTY: OPERATING GRINDERS

TASK: Grind workpiece on magnetic chuck using power feed

PERFORMANCE OBJECTIVE V-TECS 98

STANDARD: Ground workpiece must be within a tolerance of ± 0.0005" on decimal dimensions and ± 1/64" on fraction dimensions and/or meet blueprint specifications.

SOURCE OF STANDARD: Olivo. **Basic Machine Technology**, p. 15.

CONDITIONS FOR PERFORMANCE OF TASK:
Surface grinder
Magnetic chuck
Ferrous workpiece
Vernier micrometer caliper
Piece of paper
Diamond point dresser and stand
Stop blocks
Machinist's handbook
Blueprint

PERFORMANCE GUIDE

1. Clean and deburr workpiece
2. Clean and deburr magnetic chuck
3. Select grinding wheel
    a. Check workpiece material
    b. Check handbook
    c. Mount wheel
4. Dress and true grinding wheel
5. Clean magnetic chuck and place workpiece on chuck
    a. Use paper under workpiece
    b. Use stop blocks for short workpiece
    c. Mount thin pieces at an angle
    d. Contact as many chuck inserts as possible
6. Energize chuck and check rigidity of workpiece by hand
7. Adjust table reverse dogs so center of grinding wheels clears each end of workpiece by about 1"
8. Set crossfeed (usually 0.030" to 0.050")
9. Adjust table by hand until grinding wheel overlaps edge of workpiece about 1/8"
10. Start grinder
11. Lower wheelhead slowly until grinding wheel sparks the workpiece
12. Raise wheel 0.005" to clear high spots
13. Engage table feed
14. Engage crossfeed
15. Lower wheel for next cut
    a. Be sure wheel clears workpiece
    b. Use coolant
16. Finish grind to specifications
    a. Take cuts 0.0005" to 0.001"
    b. Let wheel spark out

LEARNING ACTIVITIES

1. Explain theory of selection of grinding wheels to suit metal to be ground and desired finish.
2. Demonstrate the use of stop blocks for angle contacting all chuck inserts possible.
3. Demonstrate and/or explain the adjustment of table reverse dogs for 1" clearance.
4. Discuss reading assignments.
5. Demonstrate setting cross feed and table feed, and sparking of workpiece.
6. Finish grind workpiece until wheel sparks out.

RESOURCES

Walker. **Machining Fundamentals,** p. 296.
Krar, et. al. **Technology of Machine Tools,** pp. 341-344.

EVALUATION

Written Questions

1. List two advantages of electro-magnetic chuck.
2. What are the three work-holding devices frequently used to hold work for surface grinding?

Answers

1. a. May be cut on and off with switch
   b. Holding power may be varied according to thickness of work.
2. Vise, permanent magnetic chuck, and electro-magnetic chuck.

DUTY: OPERATING GRINDERS

TASK: Grinding workpiece lined up with indicator

PERFORMANCE OBJECTIVE V-TECS 97

STANDARD: Workpiece must be aligned and ground within a tolerance of ± 0.001" on decimal dimensions and ± 1/64" on fraction dimensions and/or in accordance with blueprint specifications.

SOURCE OF STANDARD: Olivo. **Basic Machine Technology**, p. 15.

CONDITIONS FOR PERFORMANCE OF TASK:
Surface grinder
Work-holding device
Dial indicator
Surface gage
Surface plate
Angle plate
Clamps
Grinding wheel
Diamond point wheel dresser
Machined workpiece
Square
Soft hammer
Steel rule
Micrometer caliper
Blueprint

PERFORMANCE GUIDE

1. Check blueprint for surface to be ground
2. Clean surface plate and angle plate
3. Deburr workpiece
4. Place angle plate on surface plate and clamp workpiece to angle plate
5. Align workpiece level using square on surface plate
6. Align workpiece level using dial indicator on surface gage
   a. Use soft hammer to adjust workpiece
   b. Surface to be ground should be above angle plate
7. Dress and sharpen grinding wheel (Caution: wear goggles)
8. Place workpiece and angle plate on magnetic chuck
9. Grind surface of workpiece
10. Measure workpiece
    a. Accept workpiece as within specifications, or
    b. Reject workpiece and/or take corrective action

LEARNING ACTIVITIES

1. Explain use of blueprint and finish symbols to determine surface to be ground.
2. Demonstrate the use of dial indicator and angle plate/clamps to level workpiece on surface plate prior to mounting on grinder.
3. Demonstrate grinding workpiece and measuring to be sure tolerances are maintained.

PERFORMANCE OBJECTIVE V-TECS 97 continued

4. Discuss reading assignments.
5. Assign appropriate projects for skill development, i.e., 1/2" x 1" x 6" bar to be used as parallels.

RESOURCES

Walker. **Machining Fundamentals,** p. 304.
Krar, et. al. **Technology of Machine Tools,** p. 352.

EVALUATION

Written Question

What is the advantage of using a dial indicator to align cylinder grinder?

Answer

It is the most accurate method to adjust taper out of grinders.

DUTY: **OPERATING GRINDERS**

TASK: Grind radii and angles on surface grinder

PERFORMANCE OBJECTIVE V-TECS 95

STANDARD: RAdius and angle of workpiece must be to a tolerance of ± 0.001" on decimal dimensions and ± 1/64" on fraction dimensions and/or meet blueprint specifications.

SOURCE OF STANDARD: Krar and Oswald. **Grinding Technology**, pp. 131-134.
Walker. **Machining Fundamentals**; p. 19.

CONDITIONS FOR PERFORMANCE OF TASK:
- Surface grinder
- Magnetic chuck
- Radius and angle dresser
- Grinding wheel
- Height setting bar
- Gage blocks
- Diamond point dresser
- Radius gage
- Micrometer caliper
- Workpiece
- Blueprint

PERFORMANCE GUIDE

1. Check blueprint for radius and angle
2. Clean magnetic chuck and align radius dresser square
3. Set stops on dresser for length of radius
   a. Set stops 90° apart for one corner radius
   b. Set stops 180° apart for entire corner radius
4. Mount height setting bar in radius dresser and against surface of magnetic chuck (Top of bar centered in wheel dresser)
5. Wring gage blocks for radius dimension and place between height setting bar and diamond point
6. Raise diamond until it holds gage blocks and lock diamond holder (For concave radius, set diamond point above center amount equal to radius)
7. Move table to locate diamond under wheel center and lock
8. Rotate radius dresser 1/4 turn to locate diamond horizontal
9. Start grinder (Caution: wear goggles)
10. Move saddle until diamond touches side of wheel and lock
11. Stop grinder and raise wheelhead until diamond clears wheel
12. Start grinder
13. Lower wheel slowly while rotating radius dresser through 90° arc until diamond contacts wheel
14. Feed wheel down 0.002" to 0.003" for each rotation of radius dresser
15. Continue feeding and rotating until radius completed
16. To grind angle mount radius and angle dress square on magnetic chuck
17. Locate diamond under center of wheel
18. Turn on grinder
19. Adjust crossfeed until diamond touches corner of grinding wheel
20. Turn off grinder
21. Lock table

21. Lock table
22. Loosen swivel ring locking screw on dresser
23. Adjust the two swivel stop pins until required angle indicates on vernier plate
24. Swivel dresser upright in opposite direction until required angle for upper swivel ring stop pin is obtained
25. Tighten swivel ring locking screw
26. Turn on grinder
27. Move crossfeed with dresser 0.002" to 0.003" into grinding wheel
28. Feed diamond across wheel with angle traverse control handle
29. Continue cuts of 0.002" to 0.003" until wheel dressed at angle required

LEARNING ACTIVITIES

1. Explain methods of depicting radii and angles on prints and standard symbols and notations.
2. Demonstrate the use of stops in setting up to dress wheel to specified radius.
3. Demonstrate and/or explain use of wheel dresser and order of procedure in dressing radius on wheel.
4. Demonstrate and/or explain use of angle dresser and vernier plate to dress required angle on wheel.
5. Demonstrate grinding radii and angles on workpiece to blueprint specification.
6. Let students practice grinding radii and angles.

RESOURCES

Walker. **Machine Fundamentals**, p. 295.
Krar, et. al. **Technology of Machine Tools**, p. 348.

EVALUATION

Written Question

Name two methods of dressing contours and radii on grinding wheels.

Answer

Radius wheel dresser and crush form dressing

DUTY: OPERATING GRINDERS

TASK: Polish with grinding machine

PERFORMANCE OBJECTIVE V-TECS 84

STANDARD: Workpiece must be polished to blueprint specifications.

SOURCE OF STANDARD: Kentucky Writing Team, Incumbent Workers and Instructors

CONDITIONS FOR PERFORMANCE OF TASK:
Furnished with grinder
Polishing wheel
Polishing compound

PERFORMANCE GUIDE

1. Determine workpiece material
2. Select and mount polishing wheel (ring test wheel and replace if cracked)
3. Select and set speed (if applicable)
4. Secure workpiece
5. Turn on grinder
6. Apply compound to polishing wheel (wear goggles)
7. Polish workpiece
    a. Hold work securely
    b. Apply pressure at center of wheel or below
    c. Stand braced firmly
    d. Do not use gloves
8. Check polished surface of workpiece
9. Repeat steps 7-8 until workpiece polished to specifications

LEARNING ACTIVITIES

1. Explain in detail how to visually determine kinds of metal.
2. Demonstrate the mounting of polishing wheel and selection of speed.
3. Demonstrate and/or explain use of polishing compound and how to apply it to wheel.
4. Have students demonstrate and/or explain use of polishing compound and polishing.
5. Assign appropriate projects for skill development, i.e., polish tarnished tools and machine accessories.

RESOURCES

Krar, et. al. **Technology of Machine Tools**, p. 161.

EVALUATION

Written Question
List precautions while polishing on lathe.

Answers
1. Move polishing cloth slowly back and forth along work.
2. Hold cloth with one hand; apply pressure with the other.
3. Keep hands clear of chuck.

DUTY: OPERATING GRINDERS

TASK: Grind workpiece between centers

PERFORMANCE OBJECTIVE V-TECS 96

STANDARD: Woprkpiece must be ground to a tolerance of ± 0.0005" and/or blueprint specifications.

SOURCE OF STANDARD: Krar and Oswald. **Grinding Technology**, pp. 149-151.
Oberg, et. al. **Machinery's Handbook**, pp. 2016-2021.

CONDITIONS FOR PERFORMANCE OF TASK:
Cylindrical grinder
Machinist's handbook
Grinding wheel
Diamond point wheel dresser
Centers
Test bar
Dial indicator
Driving dog
Work rests
Vernier micrometer caliper
Lubricant
Workpiece

PERFORMANCE GUIDE

1. Check condition of centers (grind, lap, or replace if damaged)
2. Clean centers and center holes in test bar
3. Align centers with test bar and dial indicator
4. Adjust centers in center of table and for length of workpiece
5. Dress and true grinding wheel (wear goggles)
6. Lubricate centers
7. Place dog on workpiece and mount between centers (Avoid excessive pressure on centers)
8. Clamp driving dog on workpiece and adjust driveplate pin
9. Support long workpiece with work rests about 6 to 10 work diameter apart.
10. Start grinder and run for a few minutes (wear goggles)
11. Adjust table reverse dogs so 1/3rd wheel overhangs workpiece at each end
12. Check reference and set grinder speed
13. Check reference and set grinder work speed according to diameter and material (cutting speed)
14. Set headstock rotation counterclockwise
15. Set automatic feed mechanism, if available
16. Select and set table traverse feed (check blueprint for finish required and amount of material to be removed)
17. Start table traversing and slowly touch wheel to work
18. Grind workpiece until surface cleans up
19. Check for taper and adjust, if necessary
20. Calculate amount of material to be removed
21. Set depth of cut and grind workpiece to specifications

PERFORMANCE OBJECTIVE V-TECS 96 continued

LEARNING ACTIVITIES

1. Explain theory of grinding between centers and emphasize the importance of clean centers, alignment with test bar and dial indicator and lubrication of centers.
2. Demonstrate use of driving dog and work rests on long workpieces.
3. Demonstrate and/or explain use of table reverse dogs, grinder wheel speed, and workpiece speed and direction of rotation (counter clockwise).
4. Demonstrate setting automatic feed mechanism and speed of table traverse and depth of cut.
5. Demonstrate grinding to finish size including checking for taper or other adjustments.

RESOURCES

Walker. **Machining Fundamentals**, pp. 299-304.
Krar, et. al. **Technology of Machine Tools**, pp. 349-353.

EVALUATION

Written Questions

1. ________________ grinding mounts the work between centers and rotates it while it is in contact with grinder's wheel.
2. Name two types of cylindrical grinders.
3. Name two types of center type cylindrical grinders.

Answers

1. Cylindrical
2. Center type and centerless
3. Plain and universal

DUTY: OPERATING GRINDERS

TASK: Cut off or part material with grinding wheels

PERFORMANCE OBJECTIVE V-TECS 86

STANDARD: Parted workpiece must be within a tolerance of ± 1/64" on fraction dimensions, ± 0.005" on decimal dimensions and/or meet blueprint specifications.

SOURCE OF STANDARD: Krar and Oswald. **Grinding Technology**, p. 123.
Walker. **Machining Fundamentals**, p. 19.

CONDITIONS FOR PERFORMANCE OF TASK:
Furnished with grinder magnetic chuck
Diamond dresser
Reinforced abrasive cut off wheel
Vernier calipers
Micrometer calipers
Work-holding device
Square

PERFORMANCE GUIDE

1. Check workpiece material
2. Select cut off wheel (size, grade, and thickness)
3. Mount grinding wheel on spindle
   a. Check spacer
   b. Check guard
   c. Dress wheel
4. Mount work in work-holding device
5. Align workpiece parallel or at right angles to table, as required
6. Energize magnetic chuck
7. Move crossfeed handle to position for cut
8. Lock saddle
9. Adjust workpiece until it clears center of cut off wheel about 1"
10. Lock table, if possible
11. Place board or masonite on magnetic chuck under part to be cut off
12. Start grinder and feed workpiece steadily down until part cut off
13. Check measurement of workpiece against specified tolerances
    a. Accept workpiece, or
    b. Reject workpiece and/or take corrective action

LEARNING ACTIVITIES

1. Explain use and/or theory of operation and selection of abrasive cut off wheels (size, grade, and thickness).
2. Demonstrate the use of grinding wheels to cut off damaged portion of tool.
3. Caution students to check set up (spacer, guard, dress wheel and holding device).
4. Demonstrate down feed and measure to ensure accuracy.
5. Discuss reading assignment.

PERFORMANCE OBJECTIVE V-TECS 86 continued

RESOURCES

Krar, et. al. **Technology of Machine Tools**, p. 341.

EVALUATION

Written Questions

1. Why is cut-off operation with grinding wheel dangerous?
2. Give two advantages to cutting off with grinder wheel.

Answers

1. Wheels are thin, therefore, side pressure will cause them to shatter.
2. a. Hard, difficult to cut metal can be parted with grinder wheels.
   b. Remaining surface is smooth and straight.

POWER SAWS

DUTY: **OPERATING POWER SAWS**

TASK: Clean and lubricate power saws

PERFORMANCE OBJECTIVE V-TECS 102

STANDARD: The power saws must be cleaned and lubricated according to manufacturer's specifications and band guide must be adjusted to allow clearance of 0.001" to 0.002".

SOURCE OF STANDARD: Walker. **Machining Fundamentals**, p. 319.

CONDITIONS FOR PERFORMANCE OF TASK:
Furnished with band saw and references (manufacturer's operation manual)
Cleaner
Lubricant
Rags
Brush
Feeler gage
Wrenches
Blade guide inserts

PERFORMANCE GUIDE

1. Clean off all chips with brush
2. Clean oil and dirt from saw.
3. Lubricate saw (check manufacturer's specifications)
    a. Apply grease to fittings
    b. Apply oil to oil cups
    c. Oil slides lightly
4. Inspect saw
    a. Check tension on blade
    b. Check vertical alignment of blade
    c. Check blade for sharpness and damage
    d. Mount inserts and adjust to tolerance with feeler gage
5. Verify adjustments with short test run
    a. Approve saw adjustments, or
    b. Reject saw adjustments and adjust to specifications

LEARNING ACTIVITIES

1. Demonstrate proper cleaning and oiling procedure.
2. Discuss various oiling points.
3. Lecture on cleanliness.
4. Explain oiling process.
5. Demonstrate operating procedure.
6. Explain how to adjust band guide.

RESOURCES

Johnson. **General Industrial Machine Shop**, pp. 361-376.
Felker. **Machine Shop Technology**, p. 62.

PERFORMANCE OBJECTIVE V-TECS 102 continued

EVALUATION

Written Questions

1. Explain method used to check for blade tension.
2. In what direction does the blade rotate?
3. When and how is the blade lubricated?

Answers

1. Blade tension is checked by setting the blade tension gauge to proper setting.
2. Blade always rotates with teeth running toward stock.
3. Blade is lubricated by automatic oiler as soon as machine is turned on.

DUTY: OPERATING POWER SAWS

TASK: Select and set speeds and feeds for sawing operations

PERFORMANCE OBJECTIVE V-TECS 108

STANDARD The speed and feed for sawing operation must be selected and set as specified in machinist's handbook for workpiece.

SOURCE OF STANDARD: Oberg, et. al. **Machinery's Handbook,** 21st ed., p. 1794.

CONDITIONS FOR PERFORMANCE OF TASK:
Furnished with workpiece
Blueprint
Machinist's handbook
Manufacturer's operation manual
Band saw

PERFORMANCE GUIDE

1. Study blueprint
2. Determine material to be sawed
3. Determine type of saw to be used
4. Determine type of blade
5. Determine machine speed
   a. Check speed chart on machine, if available
   b. Check reference for cutting speed
   c. Calculate speed, if necessary
6. Set machine speed (consult manufacturer's operation manual)
7. Determine feed requirement and set feed (consult manufacturer's manual)

LEARNING ACTIVITIES

1. Determine and demonstrate feed by the amount of penetration to the speed selected.
2. Explain how machine speed (rpm) is determined.
3. Lecture on wear of blade from improper feed and speed.
4. Have students practice selecting and setting speeds and feeds for several sawing operations.
5. Discuss the computations from the students and identify the problems encountered with incorrect feeds and speeds.

RESOURCES

Felker. **Machine Shop Technology,** p. 67.
Johnson. **General Industrial Machine Shop,** p. 369.

EVALUATION

Written Questions

1. Using the table on page 370 in **General Industrial Machine Shop,** what is the cutting speed for general purpose cutting?
2. Using the table on page 364 in **General Industrial Machine Shop,** what is the feed for general purpose cutting?

PERFORMANCE OBJECTIVE V-TECS 108 continued

Answers
1. 150-175 RPM
2. Moderate

DUTY: OPERATING POWER SAWS

TASK: Cut and weld bandsaw blade

PERFORMANCE OBJECTIVE V-TECS 103

STANDARD: The cut and welded blade must be straight, annealed, and without flash.

SOURCE OF STANDARD: Walker. **Machining Fundamentals**, pp. 317-318.

CONDITIONS FOR PERFORMANCE OF TASK:
Furnished with bandsaw blade
Specifications
Welding equipment (band saw butt welder and grinder)
Tin snips

PERFORMANCE GUIDE

1. Cut off electrical power to saw
2. Remove blade tension
3. Cut blade
4. Grind blade ends square
5. Insert blades in welder jaws
    a. Point teeth in
    b. Butt ends
    c. Center in gap
    d. Clamp
6. Set pressure and weld (caution: wear goggles)
7. Loosen clamps and set for annealing
8. Clamp and anneal (dull red color)
9. Remove from welder jaws
10. Grind off flash from weld
    a. Caution: do not "dish" grind weld
    b. Caution: do not grind saw teeth
11. Check blade in thickness gage
12. Remove blade and adjust tension
13. Test run blade
    a. Accept welded blade, or
    b. Reject welded blade and make required adjustments.

LEARNING ACTIVITIES

1. Demonstrate measuring, cutting and welding bandsaw blade.
2. Demonstrate the anneal process.
3. Explain the annealng process.
4. Explain how the blade is made into a band.
5. Review safety procedures.
6. Explain the meaning of flash.

RESOURCES

Johnson. **General Industrial Machine Shop**, pp. 361-376.

PERFORMANCE OBJECTIVE V-TECS 103 continued

EVALUATION

Written Questions

1. Explain how to cut blade to proper length.
2. Explain how to set up welder.

Answers

1. Blade should be measured from end to end plus enough stock to square each end.
2. Square both ends of blade, butt up to back of welder letting the ends of the blade touch each other.

DUTY: OPERATING POWER SAWS

TASK: Cut material to length with power hack saw

PERFORMANCE OBJECTIVE V-TECS 104

STANDARD: Workpiece must be cut within a tolerance of ± 1/32".

SOURCE OF STANDARD: Olivo. **Fundamentals of Machine Technology**, p. 178.

CONDITIONS FOR PERFORMANCE OF TASK:
Furnished with power hack saw
Workpiece
References
Blueprint
Measuring tools (steel rule, square)
Wrenches
Floor stand
File
Scribe

PERFORMANCE GUIDE

1. Refer to job specifications for dimensions
2. Measure to dimensions
3. Mark location with file/scribe
4. Select saw blade (see reference)
5. Mount blade
6. Check vise with square
7. Set saw speed
8. Set saw feed
9. Clamp workpiece in vise
    a. Align blade on waste side of cut
    b. Support long pieces with floor stand
10. Start saw
11. Lower blade to workpiece and engage feed
12. Deburr workpiece and check measurement after workpiece cut
    a. Accept workpiece, or
    b. Reject workpiece.

LEARNING ACTIVITIES

1. Demonstrate proper measuring procedure.
2. Discuss various ways to cut with saw.
3. Discuss the reason for piece being cut to certain lengths.
4. Refer to Handbook for proper saw blade.
5. Review blueprint reading.

RESOURCES

Johnson. **General Industrial Machine Shop**, p. 361.
Felder. **Machine Shop Technology**, p. 62.

EVALUATION

Written Questions

1. Explain power saw set up.
2. Name three ways to cut with the power saw.

Answers

1. Workpiece should be held firm in vise. Guideline should be drawn on workpiece, select proper blade, then start saw. Advance blade against workpiece.
2. Cut off, straight swing and contour.

DUTY: OPERATING POWER SAWS

TASK: Replace saw blades

PERFORMANCE OBJECTIVE V-TECS 105

STANDARD: The replaced saw blades must be aligned and adjusted to operator's manual specifications.

SOURCE OF STANDARD: Kentucky Writing Team, Incumbent Workers and Instructors

CONDITIONS FOR PERFORMANCE OF TASK:
Furnished with saw and blade
Hand tools
References and power hack saw

PERFORMANCE GUIDE

Power Hacksaw

1. Select saw blade
2. Cut off electrical power
3. Release tension clamp
4. Remove and store old blade
5. Adjust for length of new blade
6. Insert new blade in frame
7. Insure that teeth point in direction of cut to be done
8. Tighten blade in the frame

Metal Band Saw

1. Select saw blade
2. Cut off electrical power
3. Release tension on blade
4. Remove blade
5. Loop blade for storage
6. Check guides and remove and install new guides according to operator's manual
7. Unwind new blade
8. Install new blade
9. Apply tension to blade according to operator's manual and inspect for blade direction and guide seating

LEARNING ACTIVITIES

1. Explain how to find the correct tension from the specification; demonstrate the setting.
2. Identify the correct direction of the saw blades.
3. Demonstrate how to replace the power hacksaw.
4. Demonstrate how to replace the metal bandsaw.
5. Have students practice replacing and aligning the two saw blades.

RESOURCES

Johnson. **General Industrial Machine Shop**, p. 316.
Felker. **Machine Shop Technology**, p. 62.

EVALUATION

Written Questions

1. Observe while student installs the power hacksaw; observe while student installs metal bandsaw. Use checklist for evaluation.
2. Explain method used to check for blade tension on power hacksaw and on metal band saw.
3. When and how is the blade lubricated on the power hacksaw and on metal band saw?

Answers

1. On following sheet.
2. Blade should be tightened to proper tension setting on gauge. Also when sound comes from blade when plucked like a guitar string in tune.
3. Blade should be lubricated on contact of blade to the stock through an automatic oiler.

CHECKLISTS FOR V-TECS 105 EVALUATION

1. a. Check list for installing power hacksaw:

________ Select saw blade

________ Cut off electrical power

________ Release tension clamp

________ Remove and store old blade

________ Adjust for length of new blade

________ Insert new blade in frame

________ Insure that teeth point in direction of cut to be done

________ Tighten blade in the frame

b. Check list for installing metal band saw:

________ Select saw blade

________ Cut off electrical power

________ Release tension on blade

________ Remove blade

________ Loop blade for storage

________ Check guides and remove and install new guides according to operator's manual

________ Unwind new blade

________ Install new blade

________ Apply tension to blade according to operator's manual and inspect for blade direction and guide seating

DUTY: OPERATING POWER SAWS

TASK: Saw internal contours-band saw

PERFORMANCE OBJECTIVE V-TECS 106

STANDARD: Internal cut on workpiece must be within 1/32" of scribed line to a tolerance of ± 1/64".

SOURCE OF STANDARD: Kentucky Writing Team, Incumbent Workers and Instructors.
Walker. **Machining Fundamentals**, p. 32.

CONDITIONS FOR PERFORMANCE OF TASK:
Furnished with layed out workpiece
Blueprint
References
Band saw
Blade butt welder
Band saw blade
Drill press
Drills
Center punch
Hammer
Tin snips or blade cutter

PERFORMANCE GUIDE

1. Check workpiece for sharp internal curves
2. Check minimum radius limit of blade
3. Center punch hole for inserting blade
    a. Hole must be larger than blade width
    b. Mark holes for sharp curves
4. Drill hole(s) in workpiece
5. Remove blade from bandsaw
6. Cut bandsaw blade (near original weld)
7. Insert blade through drilled hole in workpiece
8. Weld bandsaw blade
    a. Grind ends square
    b. Weld
    c. Anneal
    d. Grind off flash
9. Mount blade on bandsaw and adjust tension
    a. Point teeth down
    b. Check vertical alignment
10. Saw workpiece internally
    a. Stay 1/32" from layout line
    b. Check radius of cuts for arcs or curves
11. Turn off band saw and remove blade and workpiece
12. Cut blade (cut off original weld)
13. Remove from work and reweld blade
14. Replace blade on bandsaw and adjust tension and alignment

LEARNING ACTIVITIES

1. Explain how to determine minimum radius limit of blade.
2. Demonstrate how to center punch hole and the safety procedures.
3. Explain the procedure in welding the bandsaw blade.
4. Show how to mount the blade and adjust tension.
5. Explain the movement of the workpiece.
6. Have students practice sawing internal contours using the bandsaw and checking for correct tension and alignment.

RESOURCES

Johnson. **Machine Shop Technology**, p. 67.
Felker. **General Industrial Machine Shop**, pp. 369-371.

EVALUATION

Written Questions

1. In which direction does the bandsaw blade rotate when making internal contours?
2. Explain the process of cutting the blade apart and welding the blade back together when making internal contours.
3. Explain the method used to check for blade tension on the bandsaw when making internal contours.

Answers

1. Blade pressure will be down toward the table.
2. Blade will be cut and placed through a drilled hole in the stock.
   Blade will then be welded together and mounted back on the machine.
3. Blade will be tightened until tension dial reads proper setting.

DUTY: OPERATING POWER SAWS

TASK: Saw to scribed line

PERFORMANCE OBJECTIVE V-TECS 107

STANDARD: The workpiece must be sawed to job specifications and to within 1/32" of scribed lines.

SOURCE OF STANDARD: Kentucky Writing Team, Incumbent Workers and Instructors.

CONDITIONS FOR PERFORMANCE OF TASK:

Furnished with blueprint
Work-holding device
Band saw
Layed-out workpiece
Band saw blades
Measuring instruments

PERFORMANCE GUIDE

1. Insure that scribed lines are clear.
2. Mount and align machine guide (as required)
3. Insure that correct blade is on saw; make necessary corrections
4. Determine and set cutting speed
5. Adjust and clamp saw guide
6. Secure work in work-holding device, (as required)
7. Perform sawing operation
8. a. Support workpiece, as required
    b. Align scribed line to blade
    c. Advance workpiece into saw with steady pressure
    d. Saw to specifications (1/32" from line on waste side)
    e. Note any sharp curves

LEARNING ACTIVITIES

1. Explain and discuss the use of the measuring instruments needed for this job.
2. Discuss the proper location of blade to scribed line.
3. Review safety procedures.
4. Determine the correct blade to use on saw.
5. Demonstrate the procedure in sawing to a scribed line.
6. Have students practice sawing to scribed line.

RESOURCES

Felker. **Machine Shop Technology**, p. 67.
Johnson. **General Industrial Machine Shop**, pp. 369-373.

EVALUATION

Written Questions

1. Explain how to mount and align machine guides in the sawing operation to a scribed line.
2. Explain how to determine and set cutting speed for sawing to a scribed line.
3. Why is it important that scribed lines be clear on a layed-out workpiece before sawing?

Answers

1. Guides should be opened on slide bar wide enough to accommodate stock diameter.
2. The thickness of the steel being cut would determine cutting speed for saw.
3. This is to assure precision cutting.

LATHES

DUTY: OPERATING LATHES

TASK: Clean and lubricate lathes

PERFORMANCE OBJECTIVE V-TECS 116

STANDARD: Lathe must be cleaned and lubricated according to manufacturer's specifications.

SOURCE OF STANDARD: Olivo. **Fundamentals of Machine Technology**, p. 320.

CONDITIONS FOR PERFORMANCE OF TASK:

- Lathe
- Operator's manual
- Cleaner
- Lubricants
- Rags
- Brush
- Machinist's handbook

PERFORMANCE GUIDE

1. Shut off power to lathe
2. Clean off chips with brush
3. Clean lathe with cleaning fluid
4. Remove thick gum and grease with special solvent
5. Lubricate lathe (check manual for lubricant)
   a. Check oil levels
   b. Add oil up to index lines
   c. Fill all small oil holes and cups
   d. Wipe machined surfaces with thin oil film or rust inhibitor
6. Clean coolant system if necessary
   a. Remove chip and sediment trays and clean
   b. Siphon out coolant reservoir and clean reservoir
   c. Remove coolant nozzle and clean, then return
   d. Cool coolant pump
7. Replace coolant (check references)
8. Check coolant flow
9. Turn on power to lathe
10. Test run lathe for final check

LEARNING ACTIVITIES

1. Demonstrate cleaning chips from lathe with brush and cleaning fluid.
2. Discuss oiling point and cups (check manual).
3. Explain the different types and thicknesses of oil.
4. Demonstrate running lathe for final check.
5. Review reading assignment.

RESOURCES

Johnson. **General Industrial Machine Shop**, pp. 233-235.

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EVALUATION

Written Questions

1. What kind of brush should be used to clean the lathe?
2. Name four of the main parts in the lathe that should be cleaned.

Answers

1. A stiff bristled brush should be used to clean parts of the lathe.
2. The main parts of the lathe to be cleaned are:
   Ways
   Spindle threads
   Thread of chuck
   Spindle hole

DUTY: OPERATING LATHES

TASK: Face workpiece

PERFORMANCE OBJECTIVE V-TECS 128

STANDARD: Workpiece to be within a tolerance of ± 1/64" of the scribed line.

SOURCE OF STANDARD: Kibbe, et. al. **Machine Tool Practices**, pp. 436-442.

CONDITIONS FOR PERFORMANCE OF TASK:

Lathe
Three jaw universal chuck and chuck key
Shims
Square
Facing tool
Steel rule
Layout dye
Scriber
Blueprint

PERFORMANCE GUIDE

1. Clean and lightly oil threads on lathe spindle
2. Clean threads in chuck
3. Mount chuck on lathe spindle
4. Mount workpiece in chuck
    a. Check for true running
    b. Shim to allow true running (as required)
    c. Scribe line for length
5. Mount facing tool in tool holder
6. Adjust angle of tool holder and tool
7. Center tool to center of workpiece (vertically)
8. Lock carriage to the bed
9. Select and set speed and feed
    a. Hand feed small workpiece
    b. Power feed large workpiece
10. Face material removing 1/16" to 1/8"
11. Check to insure ends are faced square to the axis of the work
12. Face to scribed line

LEARNING ACTIVITIES

1. Discuss the various ways to mount work for facing.
2. Mount and demonstrate all the procedures in facing.
3. Explain what facing is and what facing does to workpiece.
4. Check to be sure ends are square to axis of workpiece.
5. Review the steps listed in the Performance Guide.

RESOURCES

Johnson. **General Industrial Machine Shop**, pp. 256-258.

EVALUATION

Written Questions

1. What is facing on the lathe?
2. Name three ways to mount the workpiece when facing on the lathe.

Answers

1. Facing is the operation of cutting the end face of a section at right angles to the axis of the workpiece.
2. a. In a chuck
   b. On a mandrel
   c. In a collet

DUTY: OPERATING LATHES

TASK: Set lathe speed and rough cut workpiece

PERFORMANCE OBJECTIVE V-TECS 139

STANDARD: Workpiece must meet blueprint specifications and be within a tolerance of ± 0.015" to ± 0.030".

SOURCE OF STANDARD: Giesecke, et. al. **Technical Drawing,** p. 343.
Oberg, et. al. **Machinery's Handbook,** 21st ed., pp. 1749-1764.
Walker. **Machining Fundamentals,** p. 152.

CONDITIONS FOR PERFORMANCE OF TASK:

Lathe
Work-holding device
Cutting tool
Micrometer caliper
Machinist's handbook
Workpiece
Blueprint

PERFORMANCE GUIDE

1. Identify workpiece material and size
2. Calculate speed of lathe (refer to machinist's handbook)
    a. Determine cutting speed for rough cut
    b. Use formula:

$$\text{rpm} = \frac{\text{cutting speed} \times 4}{\text{workpiece diameter}}$$

3. Calculate feed of lathe
4. Set lathe speeds and feeds
5. Measure workpiece
6. Check blueprint for designated dimension
7. Mount workpiece
8. Mount cutting tool
9. Take light cut on workpiece
10. Measure workpiece for taper, adjust as necessary
11. Rough cut workpiece
12. Measure workpiece
    a. Accept workpiece, or
    b. Reject workpiece and/or take corrective action

LEARNING ACTIVITIES

1. Have student establish workpiece size.
2. Review procedure to set feed and speed on the lathe.
3. Explain the formula and its application.
4. Demonstrate making a rough cut and show how to measure for accuracy.
5. Turn to about 1/32" over finish size with rough cut.

RESOURCES

Johnson. **General Industrial Machine Shop,** pp. 259-261.

EVALUATION

Written Questions

1. When rough cutting a workpiece, how close to the finish size should the piece be turned?
2. What is the dog used for when turning between centers on the lathe?

Answers

1. When rough cutting the size is left to about 1/32" over finish size for finishing.
2. The dog drives the work piece between centers on the lathe.

DUTY: OPERATING LATHES

TASK: Set lathe speed and finish cut workpiece

PERFORMANCE OBJECTIVE V-TECS 138

STANDARD: Workpiece must meet blueprint specifications and held to a tolerance of $\frac{+0.002''}{-0.000''}$ for work under 4" diameter.

SOURCE OF STANDARD: Giesecke, et. al. **Technical Drawing**, p. 343.
Oberg, et. al. **Machinery's Handbook**, 21st ed., pp. 1749-1764.

CONDITIONS FOR PERFORMANCE OF TASK:

Lathe
Work-holding device
Cutting tool
Micrometer
Caliper
Machinist's handbook
Rough-cut workpiece
Blueprint

PERFORMANCE GUIDE

1. Identify workpiece material and size
2. Calculate speed of lathe (refer to machinist's handbook)
   a. Determine cutting speed for finish cut
   b. Use formula

$$\text{rpm} = \frac{\text{cutting speed} \times 4}{\text{workpiece diameter}}$$

3. Calculate feed of lathe
4. Set lathe speeds and feeds
5. Measure workpiece
6. Check blueprint for designated dimension
7. Mount workpiece
8. Mount cutting tool
9. Take light cut on workpiece
10. Measure workpiece for taper, adjust as required
11. Finish cut workpiece
12. Measure workpiece
    a. Accept workpiece as within specifications, or
    b. Reject workpiece and/or take corrective action

LEARNING ACTIVITIES

1. Set up the lathe for a finish cut, set speed and feed.
2. Describe the finished diameter of workpiece.
3. Demonstrate making light cuts to check for taper.
4. Demonstrate making finish cut on the workpiece.
5. Check finished workpiece with precision measuring instrument.

RESOURCES

Johnson. **General Industrial Machine Shop**, pp. 262-264.

EVALUATION

Written Questions

1. What does "good finish details" mean?
2. What does good finish details depend on when turning a finish cut?

Answers

1. "Good finish details" means machining a surface to accurate size with a fine, smooth finish.
2. Good finish details depends on the right tool, correct feed and speed, and set of tools in tool post.

DUTY: OPERATING LATHES

TASK: Perform lathe filing

PERFORMANCE OBJECTIVE V-TECS 129

STANDARD: Diameter of workpiece must be within blueprint specifications and filed to a tolerance of ± 0.001".

SOURCE OF STANDARD: Heineman and Genevro. **Machine Tools Processes and Applications,** p. 197.

CONDITIONS FOR PERFORMANCE OF TASK:
- Lathe work-holding device
- Files
- File card
- Micrometer caliper
- Chalk
- Rags
- Blueprint

PERFORMANCE GUIDE

1. Mount workpiece in lathe
2. Set lathe rpm twice speed for normal turning
3. Disengage feed rod and lead screw
4. File workpiece
   a. Use handle on file
   b. Ride file on workpiece continuously
   c. Avoid filing near lathe dog
   d. Place rags on the ways
5. Check diameter of workpiece
6. Repeat steps 4 and 5 until workpiece is within specified tolerance

LEARNING ACTIVITIES

1. Explain why filing in a lathe is not considered a good practice.
2. Explain why the speed is adjusted to twice the rpm's of turning.
3. Demonstrate filing by moving the file at a slight right angle to the workpiece.
4. Discuss the importance of checking diameter of workpiece.
5. Review the steps listed in the Performance Guide.

RESOURCES

Johnson. **General Industrial Machine Shop,** pp. 283-284.

EVALUATION

Written Questions

1. Give two reasons why workpieces are filed on the lathe.
2. What tool is used to clean the file on the lathe?

Answers

1. Workpieces are filed on lathe to remove burrs and sharp edges and to prepare surface for polishing.
2. The file card is used to clean the file.

DUTY: OPERATING LATHES

TASK: Polish workpiece

PERFORMANCE OBJECTIVE V-TECS 130

STANDARD: The polished diameter to be within ± 0.0005" tolerance of the blueprint specifications.

SOURCE OF STANDARD: Heineman and Genevro. **Machine Tools Processes and Applications,** p. 198.

CONDITIONS FOR PERFORMANCE OF TASK:

Lathe
Work-holding device
Abrasive cloth
Cutting oil
File
Vernier micrometer caliper
Blueprint
Workpiece filed to within 0.002" to 0.003" of finished diameter

PERFORMANCE GUIDE

1. Mount workpiece in lathe
2. Set lathe rpm twice speed for normal turning
3. Disengage feed rod and lead screw
4. Polish workpiece
   a. Place rags on lathe bed
   b. Apply cutting oil
   c. Wrap abrasive cloth around file
5. Repeat step 4 until workpiece is within specified tolerance

LEARNING ACTIVITIES

1. Demonstrate mounting of the workpiece.
2. Explain why tailstock center should not be too tight.
3. Discuss why rpm should be twice as much as the cutting speed.
4. Show how to polish workpiece.
5. Explain why an abrasive cloth should be wrapped around the ends of the file.*

RESOURCES

Johnson. **General Industrial Machine Shop,** pp. 284-285.

EVALUATION

Written Question

Why would the machine speed be twice the speed of cutting for polishing?

Answer

The polishing speed should be twice the cutting speed to give a high gloss finish.

*S.C. Curriculum Writing Teams does not recommend wrapping an abrasive cloth around the entire file, only the ends.

DUTY: OPERATING LATHES

TASK: Drill holes with lathe

PERFORMANCE OBJECTIVE V-TECS 127

STANDARD: Drilled hole must be within blueprint specifications with a tolerance of ± 0.005" for drills up to 1" diameter.

SOURCE OF STANDARD: Oberg, et. al. **Machinery's Handbook**, 21st ed., p. 1669.

CONDITIONS FOR PERFORMANCE OF TASK:

Lathe
Lathe chuck
Cutting tool
Center drill
Drills
Lubricant
Drill chuck and key
Drill gage
Narrow rule
Hole gage
Micrometer caliper
Blueprint

PERFORMANCE GUIDE

1. Mount workpiece in lathe chuck
2. Select and set speed (repeat in steps 3-5, as necessary)
3. Face and center drill workpiece (use lubricant)
4. Select drill (check size with drill gage)
5. Drill workpiece to specifications
    a. Apply lubricant as required
    b. Check depth required
    c. Use tailstock spindle graduations for depth adjustment
    d. Measure depth with narrow rule
6. Measure drilled hole
    a. Accept workpiece, or
    b. Reject workpiece

LEARNING ACTIVITIES

1. Demonstrate how to face and center drill workpiece.
2. Explain how to select proper size drill to be used.
3. Show how to apply cutting oil.
4. Proceed to drill, backing out every so often to relieve shavings.
5. Explain why it is necessary to keep the workpiece lubricated.

RESOURCES

Johnson. **General Industrial Machine Shop**, pp. 273-276.

EVALUATION

Written Questions

1. Why is the center drill used first when drilling a hole in the lathe?
2. Why would you not steady the drill with your hands?

Answers

1. By center drilling the workpiece first, the drill will penetrate straight.
2. The drill could break and cause injury to the operator.

DUTY: OPERATING LATHES

TASK: Align lathe centers using accurate measurement techniques

PERFORMANCE OBJECTIVE V-TECS 109

STANDARD: Centers must be aligned to a tolerance of ± 0.0005".

SOURCE OF STANDARD: Walker. **Machining Fundamentals**, p. 158.

CONDITIONS FOR PERFORMANCE OF TASK:

Lathe
Test bar
Centers
Dial indicator
Wrenches

PERFORMANCE GUIDE

1. Clean centers and spindle holes
2. Mount centers
3. Check alignment of center in headstock
    a. Regrind untrue hardened center
    b. Turn untrue soft center
4. Check index marks on tailstock
5. Check centers together for rough alignment
6. Mount test bar between centers
7. Mount indicator on tool post
8. Check indicator against test bar
    a. Line indicator on center height
    b. Move indicator against test bar about 0.010"
9. Set indicator dial at zero at one end of test bar
10. Check test bar with dial indicator at each end
11. Adjust tailstock to tolerance required

LEARNING ACTIVITIES

1. Demonstrate procedures in cleaning and mounting centers.
2. Demonstrate aligning centers by bringing centers together.
3. Explain aligning tail stock by index marks
4. Demonstrate aligning centers using the dial indicator.
5. Review reading assignment.

RESOURCES

Johnson. **General Industrial Machine Shop**, pp. 256-258.

EVALUATION

Written Questions

1. What is the center in the head stock of the lathe called?
2. What is the tail stock center of the lathe called?

Answers

1. The head stock center is called a live center.
2. The tailstock center is called a dead center.

DUTY: OPERATING LATHES

TASK: Turn workpiece between centers on the lathe.

PERFORMANCE OBJECTIVE V-TECS 145

STANDARD: Workpiece must be within tolerance of ± 0.005" on decimal dimensions and ± 1/64" on fraction dimensions and/or meet blueprint specifications.

SOURCE OF STANDARD: Giesecke, et. al. **Technical Drawing**, pp. 339, 343.
Kibbe, et. al. **Machine Tool Practices**, pp. 446-451.

CONDITIONS FOR PERFOMANCE OF TASK:

Lathe
Lathe chuck
Lathe centers
Lathe tools
Centerdrill
Lubricant
Lathe dog
Driveplate
Micrometer caliper
Test bar
Dial indicator
Wrenches
Lubricant
Machinist's handbook
Layout dye
Scriber
Steel rule
Blueprint
Workpiece

PERFORMANCE GUIDE

1. Mount workpiece in chuck
2. Face and center drill ends
3. Mount drive plate and centers on lathe
4. Check center alignment (adjust, as required)
5. Mount workpiece between centers with lathe dog attached
6. Locate tailstock and adjust center (lock both and lubricate center as required)
7. Check workpiece material
8. Calculate and set speed
9. Layout end of cut
10. Mount lathe tool and holder
    a. Set tool to swing away from workpiece
    b. Check mounting at start of cut
    c. Check mounting at lathe dog for clearance
11. Set lathe feed for rough cut
12. Start lathe and take trial cut short distance

13. Stop lathe and measure workpiece
14. Start lathe
15. Adjust depth and rough cut 0.020" to 0.030" oversize
16. Measure workpiece for taper and size
17. Set lathe feed for finish cut
18. Mount finishing tool
19. Machine to designated dimension

LEARNING ACTIVITIES

1. Demonstrate mounting face plate and centers in lathe.
2. Review how to mount workpiece between centers.
3. Explain the purpose of the lathe dog.
4. Have student set work speed and feed.
5. Demonstrate making trial and finish cuts.

RESOURCES

Johnson. **General Industrial Machine Shop**, pp. 259-265.

EVALUATION

Written Questions

1. What is the purpose of the lathe dog?
2. Describe how to align workpiece between centers on the lathe.

Answers

1. The lathe dog gives the work its drive.
2. Proper use of dial indicator and test bar on workpiece between the centers will assure a precision cut.

DUTY: **OPERATING LATHES**

TASK: Knurl parts with lathe

PERFORMANCE OBJECTIVE V-TECS 132

STANDARD: The knurl must meet blueprint specifications and a tolerance of ± 1/64" on fraction dimensions.

SOURCE OF STANDARD: Walker. **Machining Fundamentals**, pp. 191-192.
Olivo. **Basic Machine Technology**, pp. 380-381.

CONDITIONS FOR PERFORMANCE OF TASK:
Lathe
Toolholder
Workpiece
Knurling tool
Cutting tool
Layout dye
Scriber
Cutting oil
Micrometer caliper
Steel rule
Work-holding device
Brush
Blueprint

PERFORMANCE GUIDE

1. Mount workpiece in lathe
2. Lay off length of knurl
3. Calculate work diameter to be knurled
    a. Number of serrations = $(21 \times \pi)$ (D - 0.017")
    (D = finished diameter) ($\pi = 3.14$)
    b. O.D. = (number of serrations) x (0.015")
    (O.D. = turned diameter to be knurled)
4. Set lathe speed and feed
5. Turn workpiece to O.D.
6. Select and mount knurling tool
7. Position and align knurling tool
8. Set lathe speed and feed
    a. Speed about ½ rpm of turning speed
    b. Feed about 0.020"
9. Start lathe and feed knurl into workpiece
10. Check pattern and adjust as required
11. Knurl workpiece
    a. Keep feed engaged
    b. Keep knurling tool engaged with workpiece
    c. Reverse lathe and knurl
    d. Use cutting oil
12. Clean knurl and measure workpiece
    a. Accept workpiece, or
    b. Reject workpiece and/or take corrective action

PERFORMANCE OBJECTIVE V-TECS 132 continued

LEARNING ACTIVITIES

1. Discuss setting lathe feed and speed.
2. Tell how to select knurling tool to be used.
3. Demonstrate starting lathe and feeding in knurling tool.
4. Check pattern and adjust as required.
5. Show how to clean knurled piece.

RESOURCES

Johnson. **General Industrial Machine Shop**, pp. 282-283.

EVALUATION

Written Question

Give two uses of a knurl.

Answer

Knurls are used for ornament and for hand grip.

DUTY: **OPERATING LATHES**

TASK: Machine part for precision fit

PERFORMANCE OBJECTIVE V-TECS 133

STANDARD: Machined part must be within a tolerance of ± 0.0005" on decimal dimensions and ± 1/64" on fraction dimensions and/or meet blueprint specifications.

SOURCE OF STANDARD: Oberg, et. al. **Machinery's Handbook,** 21st ed., p. 1536.

CONDITIONS FOR PERFORMANCE OF TASK:

Lathe
Work-holding device
Vernier micrometer caliper
Lathe turning tool and holder
File
Abrasive paper
Layout dye
Scriber
Inside micrometer
Machinist's handbook
Blueprint

PERFORMANCE GUIDE

1. Measure hole in workpiece to be fitted
2. Check blueprint for fit required
3. Check handbook for tolerance and allowance
4. Mount workpiece to be machined in lathe
5. Lay off surface to be machined
6. Mount lathe tool and toolholder
7. Turn workpiece to within 0.002" of final diameter
8. File and polish workpiece to specified dimensions

LEARNING ACTIVITIES

1. Discuss hole size in workpiece to be fitted.
2. Have students study the blueprint and identify the fit required.
3. Show how to prepare surface to be machined.
4. Demonstrate turning workpiece (within .002).
5. Demonstrate filing and polishing workpiece.

RESOURCES

Johnson. **General Industrial Machine Shop,** pp. 262-264.

EVALUATION

Written Question

Name two precision tools used to measure precision fits.

Answer

The micrometer and the vernier caliper are used to measure precision fits.

DUTY: OPERATING LATHES

TASK: Align workpiece in four jaw chuck

PERFORMANCE OBJECTIVE V-TECS 110

STANDARD: Workpiece must be aligned to a tolerance of ± 0.001".

SOURCE OF STANDARD: Walker. **Machining Fundamentals**, pp. 164-166.

CONDITIONS FOR PERFORMANCE OF TASK:
Lathe
Workpiece
Four jaw independent chuck
Dial indicator
Chalk
Wrenches

PERFORMANCE GUIDE

1. Mount workpiece in four jaw chuck using rings on face of chuck for rough alignment
2. Center workpiece with chalk using two opposite jaws for each adjustment
   a. Mount toolholder in toolpost
   b. Rest chalk on toolholder
   c. Rotate workpiece holding chalk against workpiece
3. Mount indicator on toolpost
4. Check one pair of opposite jaws with indicator against workpiece
5. Adjust one-half of error
6. Check other opposite jaws and adjust one-half error
7. Repeat steps 4-6 until workpiece is within tolerance and all jaws are tightened
8. Recommend workpiece within or without designated tolerance
   a. Accept workpiece, or
   b. Reject workpiece and/or take corrective action

LEARNING ACTIVITIES

1. Demonstrate setting up workpiece in four jaw chuck using the rings on the face of the chuck.
2. Demonstrate centering work with chalk.
3. Explain the dial indicator and how to center work with it.
4. Demonstrate the plus and minus readings on indicator.
5. Review reading assignment.

RESOURCES

Johnson. **General Industrial Machine Shop**, pp. 268-269.

EVALUATION

Written Questions

1. What is a lathe independent four jaw chuck?
2. Why is the dial indicator used to line up the workpiece in four jaw chuck?

Answers

1. An independent four jaw chuck is a chuck in which each jaw moves separately.
2. Using the dial indicator with the four jaw chuck will align the work precisely.

DUTY: OPERATING LATHES

TASK: Bore holes with lathe

PERFORMANCE OBJECTIVE V-TECS 112

STANDARD: Bored hole must be within a tolerance of ± 1/64" on fraction dimensions and ± .003" on decimal dimensions and/or to blueprint specifications.

SOURCE OF STANDARD: Walker. **Machining Fundamentals**, pp. 19, 187.

CONDITIONS FOR PERFORMANCE OF TASK:

Lathe
Lathe chuck
Lathe cutting tools
Boring bar
Combination drill and countersink
Drills
Chuck
Telescoping gage
Micrometer calipers
Steel rule
Wrenches

PERFORMANCE GUIDE

1. Chuck workpiece in lathe
2. Select and set lathe speed (repeat in steps 3-12, as needed)
3. Face and square workpiece
4. Center drill workpiece
5. Step drill workpiece to within 1/8" of bore diameter
6. Select boring bar (large as possible)
7. Select boring tool
    a. Check for sharpness
    b. Check for clearance
8. Mount boring bar with tool on center height
9. Start lathe
10. Move tool to workpiece and take light cut
    a. Note end of cut on boring bar
    b. Leave tool at cross slide setting when removing from cut
11. Measure bored hole
12. Take additional cuts until bored to designated dimension (Note cross feed readings are reverse of turning outside diameter)

LEARNING ACTIVITIES

1. Demonstrate how to face and square workpiece.
2. Demonstrate how to center drill work.
3. Explain why you pilot drill workpiece.
4. Lecture on selecting and mounting boring bar.
5. Demonstrate how to take cuts until bored to designated dimensions.

PERFORMANCE OBJECTIVE V-TECS 112 continued

RESOURCES

Johnson. **General Industrial Machine Shop**, pp. 275-278.

EVALUATION

Written Questions

1. Why is the workpiece center drilled first before boring a hole with the lathe?
2. Why is the workpiece pilot drilled before boring a hole with a lathe?

Answers

1. By center drilling the workpiece first, all boring tools will be in the center of work and be true.
2. The workpiece is pilot drilled first so that the boring tools will have a guide to follow.

DUTY: OPERATING LATHES

TASK: Countersink holes using lathe

PERFORMANCE OBJECTIVE V-TECS 118

STANDARD: The countersink hole must be within tolerance of ± 1/64" on fraction dimensions and ± 1° on angular dimensions and/or within blueprint specifications.

SOURCE OF STANDARD: Olivo. **Fundamentals of Machine Technology,** p. 264.

CONDITIONS FOR PERFORMANCE OF TASK:

Lathe
Lathe chuck
Combination drill and countersink
Drills
Drill chuck and key
Lathe tool
Countersink tool
Steel rule
Protractor
Toolholder
Workpiece
Blueprint

PERFORMANCE GUIDE

Using Countersink Cutter

1. Chuck workpiece in lathe
2. Select and set lathe speed (repeat in steps 3-6, as needed)
3. Face and square workpiece
4. Center drill workpiece
5. Drill workpiece
6. Countersink to blueprint specifications
    a. Use lubricant as required
    b. Reduce speed
    c. Set stop as required
    d. Check measurements during operation

Using Lathe Cutter Bit

1. Follow steps 1 to 5 under countersink cutter
2. Set compound rest angle
3. Mount cutter on center in toolholder
4. Feed tool with compound rest
5. Check angle and reset if necessary
6. Countersink to blueprint specifications
    a. Use lubricant as required
    b. Reduce speed
    c. Set stop as required
    d. Check measurements during operation

PERFORMANCE OBJECTIVE V-TECS 118 continued

LEARNING ACTIVITIES

1. Demonstrate how to chuck the work and set lathe speed.
2. Demonstrate how to square and face workpiece.
3. Demonstrate center drilling of workpiece.
4. Demonstrate drilling and countersinking to blueprint specifications.
5. Review reading assignment.

RESOURCES

Johnson. **General Industrial Machine Shop**, pp. 254-255.

EVALUATION

Written Questions

What are the two functions of the center drill?

Answer

The center drill is used as a pilot drill or a countersink.

DUTY: OPERATING LATHES

TASK: Counterbore holes using lathe

PERFORMANCE OBJECTIVE V-TECS 117

STANDARD: Hole must be counterbored to a tolerance of ± 1/64" on fraction dimensions and ± 0.003" on decimal dimensions and/or to blueprint specifications.

SOURCE OF STANDARD: Olivo. **Fundamentals of Machine Technology**, p. 428.
Walker. **Machining Fundamentals**, p. 19.

CONDITIONS FOR PERFORMANCE OF TASK:
- Lathe
- Chuck
- Faced stock with drilled hole
- Boring bar
- Telescoping gage
- Micrometer caliper
- Left hand boring tool
- Depth micrometer
- Steel rule
- Blueprint

PERFORMANCE GUIDE

1. Mount workpiece in lathe
2. Mount boring bar
   a. Select largest bar possible
   b. Grip bar short
   c. Insert boring tool in 45° position
3. Adjust boring bar and carriage stops
4. Make roughing cuts
5. Check roughing dimensions
6. Measure depth and diameter of counterbore
7. Finish bore to specified dimensions

LEARNING ACTIVITIES

1. Demonstrate mounting workpiece in lathe.
2. Discuss mounting boring bar.
3. Demonstrate making rough cut.
4. Discuss measuring for depth and diameter of counterbore.
5. Review reading assignment.

RESOURCES

Johnson. **General Industrial Machine Shop**, pp. 276-277.

EVALUATION

Written Question

Name two types of boring tools used in the lathe.

Answer

Two types of boring tools are the recess boring cutter and the regular boring bar.

DUTY: OPERATING LATHES

TASK: Ream holes with lathe

PERFORMANCE OBJECTIVE V-TECS 136

STANDARD: Reamed hole must be within blueprint specifications and within a tolerance of $\frac{+0.0005''}{-0.0000''}$.

SOURCE OF STANDARD: Oberg, et. al. **Machinery's Handbook,** 21st ed., p. 1656.

CONDITIONS FOR PERFORMANCE OF TASK:

Lathe
Work-holding device
Drills
Centerdrill
Reamers
Vernier micrometer caliper
Lubricant
Hole gage
Drill chuck and key
Lathe tool
Machinist's handbook
Plug gage
Blueprint
Workpiece

PERFORMANCE GUIDE

1. Identify workpiece material and hole diameter
2. Set lathe speed for drilling
3. Mount workpiece in lathe
4. Mount drill chuck and centerdrill in tailstock of lathe
5. Set lathe speed
6. Start lathe and face workpiece
7. Center drill workpiece
8. Select drill
    a. Drill hole undersize
    b. Step drill
9. Select reamer
10. Set lathe speed to one-half drilling speed
11. Ream hole in workpiece using lubricant as required
    a. Mount reamer in tailstock drill chuck
    b. Feed reamer into drilled hole at moderate rate
12. Measure hole and check with plug gage
    a. Approve workpiece as within specifications, or
    b. Reject workpiece

PERFORMANCE OBJECTIVE V-TECS 136 continued

LEARNING ACTIVITIES

1. Identify hole diameter.
2. Discuss mounting drill chuck in tail stock.
3. Demonstrate making center drill selection.
4. Perform facing and center drilling operation.
5. Demonstrate drilling hole to .015 under specification size.
6. Demonstrate using reamer with proper amount of lubricate.
7. Measure hole with plug gage.

RESOURCES

Johnson. **General Industrial Machine Shop**, pp. 278-279.

EVALUATION

Written Questions

1. Define "reaming".
2. How much smaller should the drill for reaming be?

Answers

1. Reaming is making an existing hole smoother and more accurate.
2. The drilled hole should never be any smaller than .015 under reamer size.

DUTY: **OPERATING LATHES**

TASK: Tap hole with lathe

PERFORMANCE OBJECTIVE V-TECS 143

STANDARD: The tapped hole must meet blueprint specifications and fit a GO and NO-GO thread plug gage.

SOURCE OF STANDARD: Oberg, et. al. **Machinery's Handbook,** 21st ed., p. 1918.

CONDITIONS FOR PERFORMANCE OF TASK:

- Lathe
- Lathe center
- Lathe chuck
- Lathe tool
- Center drill
- Drill taps
- Tap wrench
- Cutting oil
- GO and NO-GO thread plug gage
- Machinist's handbook
- Drill chuck
- Blueprint
- Workpiece

PERFORMANCE GUIDE

1. Mount workpiece in lathe
2. Face and square workpiece
3. Center drill workpiece
4. Drill hole with tap drill
5. Chamfer hole
6. Select and secure taper tap and tap wrench
7. Mount center in tailstock
8. Start tap in hole (hold tailstock center against end of tap)
9. Tap hole in workpiece
   a. Apply lubricant
   b. Back tap occasionally to break chips
   c. Clean out chips
10. Tap with plug and bottom taps
11. Clean out tapped hole
12. Measure hole with GO and NO-GO gage.
    a. Accept workpiece as within specifications, or
    b. Reject workpiece

LEARNING ACTIVITIES

1. Review how to mount and face workpiece.
2. Explain how to find tap drill for the appropriate size tap.
3. Have student select proper tap and wrench for job.
4. Demonstrate tapping hole with the three taps of a set.
5. Show how to check hole with GO-NO GO gage.

RESOURCES

Johnson. **General Industrial Machine Shop**, pp. 201-206.

EVALUATION

Written Questions

1. Explain how the size of the tap drill is determined and when it is used.
2. Name the three taps of a set.

Answers

1. The tap drill is a drill which is smaller in diameter than the tap to be used. The tap drill is used first.
2. The starter, plug, and bottoming taps are in the three-tap set.

DUTY: OPERATING LATHES

TASK: Cut external taper with compound rest

PERFORMANCE OBJECTIVE V-TECS 123

STANDARD: The tapered surface must meet blueprint specifications and fit taper ring gage.

SOURCE OF STANDARD: Olivo. **Basic Machine Technology**, p. 12.

CONDITIONS FOR PERFORMANCE OF TASK:
Lathe
Lathe dog
Taper ring gage
Center drill
Lathe tool
Lathe chuck and key
Micrometer caliper
Lay out dye
Steel rule
Prussian blue
Blueprint

PERFORMANCE GUIDE

1. Chuck workpiece on lathe
2. Select and set speed (repeat in steps 3-9, as needed)
3. Face and center drill workpiece
4. Secure workpiece between centers
5. Set compound rest to blueprint specifications (one half included angle)
6. Set up tool for cutting
    a. Set on center height
    b. Lock carriage
    c. Layout end of cut
7. Make roughing cut feeding compound rest by hand
8. Measure workpiece and make adjustments
9. Finish cut to specifications

LEARNING ACTIVITIES

1. Demonstrate facing and center drilling.
2. Explain mounting workpiece between centers.
3. Demonstrate setting up compound rest.
4. Demonstrate making rough cut by hand.
5. Discuss making finish to specifications.

RESOURCES

Johnson. **General Industrial Machine Shop**, pp. 285-294.

EVALUATION

Written Questions

1. Name two kinds of tapers used with the lathe.
2. How many degrees is the compound rest required to swivel in order to turn a taper with an included angle of 45° 30'?

PERFORMANCE OBJECTIVE V-TECS 123 continued

Answers

1. Two kinds of tapers used in the shop are Morse standard and Jarno standard.
2. Solution:

$$\text{angle with centerline} = \frac{\text{included angle}}{2}$$

$$= \frac{45^\circ\,30'}{2} = 22^\circ\,45'$$

DUTY: **OPERATING LATHES**

TASK: Cut tapers by offset tailstock

PERFORMANCE OBJECTIVE V-TECS 124

STANDARD: Taper must be within a tolerance of ± 1/64" on fraction dimension and fit a tapered ring gage.

SOURCE OF STANDARD: Kibbe, et. al. **Machine Tool Practices**, pp. 508-511.
Olivo. **Fundamentals of Machine Technology**, pp. 392-394.

CONDITIONS FOR PERFORMANCE OF TASK:
Lathe
Taper ring gage
Micrometer caliper
Wrenches
Steel rule
Turning tool
Dial indicator and base
Layout dye
Scriber
File
Abrasive cloth
Lathe dog
Drive plate
Blueprint

PERFORMANCE GUIDE

1. Mount dial indicator on compound rest of lathe
2. Adjust carriage so dial indicator pointer touches centerline of tailstock spindle
3. Adjust cross slide in about 0.010"
4. Set dial indicator on zero
5. Calculate tailstock set over from blueprint dimensions

$$\text{Offset} = \frac{L \times (D-d)}{2 \times l}$$

D = diameter at large end of taper
d = diameter at small end of taper
L = total length of workpiece
l = length of taper

6. Loosen tailstock clamp and adjust tailstock
7. Tighten tailstock clamp and place workpiece between centers
    a. Check lathe dog for clearance
    b. Check and lubricate tailstock center if necessary
8. Check witness marks on tailstock with rule
9. Set lathe speed and feed
10. Mark off length of taper

PERFORMANCE OBJECTIVE V-TECS 124 continued

11. Machine rough cut on taper of workpiece
    a. Set tool on center height
    b. Allow for adjustment and finish cut
12. Measure diameters of workpiece at one inch interval
13. Check taper per inch with taper required
14. Adjust (as required)
    a. Apply Prussian blue for gage check
    b. Make finishing cuts
15. File and polish to specifications (check with gage)

LEARNING ACTIVITIES

1. Demonstrate setting up work between centers.
2. Demonstrate method used to move tailstock.
3. Demonstrate making rough cut on taper of workpiece.
4. Check workpiece at one inch intervals.
5. Check taper per inch.
6. Adjust the tailstock if taper is not correct. Demonstrate the procedure.

RESOURCES

Johnson. **General Industrial Machine Shop,** pp. 288-290.

EVALUATION

Written Question

Name two methods used to measure the tailstock offset.

Answer

Measuring tailstock set over with a scale and the tailstock set off center lines are used to measure the tailstock offset.

DUTY: OPERATING LATHES

TASK: Cut a long external tapered surface with taper attachment

PERFORMANCE OBJECTIVE V-TECS 119

STANDARD: The taper must be to a tolerance of ± 1/64" in length and fit a GO and NO GO taper ring gage.

SOURCE OF STANDARD: Walker. **Machining Fundamentals**, pp. 19, 178.

CONDITIONS FOR PERFORMANCE OF TASK:

Lathe
Taper attachment
Cutting tool
Files
Center drill
Drill chuck and key
GO and NO GO taper ring gage
Micrometer caliper
Steel rule
Blueprint
Workpiece

PERFORMANCE GUIDE

1. Chuck workpiece on lathe
2. Select and set speed (repeat in steps 3-7 as needed)
3. Face and center drill workpiece
4. Secure workpiece between centers
5. Set taper attachment
    a. Position taper attachment allowing for length of taper and clamp
    b. Set attachment for taper required (see print and/or calculate)
    c. Position tool on center height of workpiece
    d. Engage feed 1/2" before start of cut (for backlash)
6. Make roughing cut
7. Measure workpiece and make required adjustments
8. Check workpiece with GO and NO GO gage
9. Finish cut to specifications

LEARNING ACTIVITIES

1. Demonstrate different ways to mount work in lathe.
2. Explain and demonstrate facing and center drilling workpiece.
3. Demonstrate mounting workpiece between centers.
4. Discuss setting up taper attachment.
5. Explain how to measure and make adjustments.

RESOURCES

Johnson. **General Industrial Machine Shop**, pp. 285-294.

EVALUATION

Written Question

How far out should you engage the feed before starting the cut on an external taper? Why?

Answer

The feed should be engaged at least 1/2" before starting cut. By engaging the feed 1/2" before starting cut, the possibility of a backlash is eliminated.

DUTY: **OPERATING LATHES**

TASK: Cut internal tapered surfaces with taper attachment

PERFORMANCE OBJECTIVE V-TECS 121

STANDARD: The tapered surface must be machined according to blueprint specifications and fit a tapered plug gage.

SOURCE OF STANDARD: Walker. **Machining Fundamentals**, p. 177.

CONDITIONS FOR PERFORMANCE OF TASK:

Lathe
Chuck
Workpiece
Drill chuck and key
Dial indicator
Drills
Center drill
Boring bar with tool
Lathe taper attachment
Tapered plug gage
Telescoping gage
Micrometer caliper
Steel rule
Machinist's handbook
Lubricant
Prussian blue
Blueprint

PERFORMANCE GUIDE

1. Calculate taper for taper attachment from references
2. Chuck workpiece in lathe
3. True workpiece with dial indicator
4. Select and set speeds (repeat in steps 4-10), as necessary
5. Center drill workpiece
6. Step drill to blueprint specifications
7. Mount boring bar holder and boring bar with tool on compound rest
8. Adjust lathe taper attachment
   a. Set swivel bar
   b. Tighten binding screw
   c. Check cross slide
   d. Lubricate taper attachment
9. Position boring bar and tool to blueprint specifications (set center height)
10. Turn taper and check for accuracy
11. Take additional cuts, checking workpiece with Prussian blue and taper plug gage
12. Finish cut to specifications

PERFORMANCE OBJECTIVE V-TECS 121 continued

LEARNING ACTIVITIES

1. Demonstrate chucking and truing workpiece and aligning with dial indicator.
2. Demonstrate how to step drill for hole size.
3. Discuss mounting boring bar and holder on compound rest.
4. Explain adjusting the taper attachment.
5. Demonstrate truing taper and check for accuracy.

RESOURCES

Felker. **Machine Shop Technology**, pp. 229-231.

EVALUATION

Written Questions

1. Why is it necessary to step drill before tapering internal on the lathe?
2. What is the name of the gage used to check internal tapers?

Answers

1. It is necessary to step drill to get the diameter of the small end (one closer to chuck) accurate.
2. A taper plug gage is used to check internal tapers being cut.

DUTY: OPERATING LATHES

TASK: Die cut threads with lathe, hand threading

PERFORMANCE OBJECTIVE V-TECS 125

STANDARD: Threaded workpiece must be to blueprint specifications and fit a thread gage or mating nut.

SOURCE OF STANDARD: Kibbe, et. al. **Machine Tool Practices**, pp. 82-84.

CONDITIONS FOR PERFORMANCE OF TASK:
Lathe
Lathe chuck
Lathe tool
Dies
Diestock
Thread ring gage or mating nut
Layout dye
Scriber
Steel rule
Cutting oil
Blueprint

PERFORMANCE GUIDE

1. Mount workpiece in lathe chuck
   a. Diameter should be 0.002" to 0.005" undersize
   b. End should be chamfered 45° for approximately ½ pitch of thread
   c. Mark off length of thread on workpiece
2. Select and assemble die and diestock
   a. Set die oversize for first cut with adjustable die
   b. Check condition of thread chasers
3. Mount diestock assembly on workpiece
   a. Start thread with lead side of die
   b. Place tailstock spindle against die assembly
4. Cut threads on workpiece
   a. Apply cutting oil
   b. Apply light pressure with tailstock spindle to start die straight
   c. Make first cut
   d. Check thread fit
   e. Adjust die and cut to specifications
5. Measure workpiece with thread ring gage or mating nut
   a. Accept workpiece, or
   b. Reject workpiece and/or take corrective action

LEARNING ACTIVITIES

1. Prepare and align workpiece with students watching.
2. Demonstrate how to measure workpiece to be threaded.
3. Explain how to select and assemble die and diestock.
4. Demonstrate cutting threads on workpiece.
5. Discuss proper depth of threads.
6. Show students how to check thread fit.

PERFORMANCE OBJECTIVE V-TECS 125 continued

RESOURCES

Johnson. **General Industrial Machine Shop**, pp. 198-200.

EVALUATION

Written Questions

1. Name two types of dies in the machine trade?
2. What is the name of the tool used to hold the die?

Answers

1. The adjustable and solid dies are two types of dies used in the machine trade.
2. The die stock is used to hold the die.

DUTY: OPERATING LATHES

TASK: Die cut threads with lathe using die heads

PERFORMANCE OBJECTIVE V-TECS 126

STANDARD: Threaded workpiece must meet blueprint specifications and fit a GO and NO-GO thread ring gage.

SOURCE OF STANDARD: Kentucky Writing Team, Incumbent Workers and Instructors.
Kibbe, et. al. **Machine Tool Practices,** p. 96.

CONDITIONS FOR PERFORMANCE OF TASK:
Lathe
Lathe chuck
Die head
Round machined workpiece
Lathe tool
GO and NO-GO thread ring gage
Steel rule
Blueprint

PERFORMANCE GUIDE

1. Mount workpiece in lathe chuck
2. Chamfer end of workpiece
3. Select die head and chasers
4. Mount chasers on die head
5. Mount die head
6. Set machine speed
7. Set stops
8. Close chasers with die head handle
9. Start lathe
10. Engage workpiece with die head
11. Thread workpiece
12. Check length and fit of thread
13. Adjust die head as required and cut to specifications
14. Measure workpiece and check with GO and NO-GO gage
    a. Accept workpiece, or
    b. Reject workpiece and/or take corrective action

LEARNING ACTIVITIES

1. Secure workpiece in chuck and chamfer work end with students watching.
2. Demonstrate how to position diehead.
3. Demonstrate threading workpiece.
4. Check length and fit of threads and explain how to adjust.
5. Review how to check the threads with GO-NO GO gage.
6. Discuss and review all steps given in the Performance Guide.

RESOURCES

Johnson. **General Industrial Machine Shop,** pp. 199-200.

EVALUATION

Written Question

What are the blades of the automatic die cutter made of that are located on the shaper?

Answer

The blades of the automatic die cutter are made of carbon steel and high speed steel.

DUTY: OPERATING LATHES

TASK: Make contour cut with lathe

PERFORMANCE OBJECTIVE V-TECS 135

STANDARD: Workpiece must meet blueprint specifications and fit template or gage.

SOURCE OF STANDARD: Olivo. **Basic Machine Technology**, pp. 360-361.

CONDITIONS FOR PERFORMANCE OF TASK:

Lathe
Work-holding device
Lathe tools
Radius gage
Micrometer caliper
Steel rule
Grinder
Layout dye
Scriber
Blueprint

PERFORMANCE GUIDE

1. Mount workpiece on lathe
2. Select lathe tool
3. Select radius gage
4. Grind tool to fit radius gage
5. Lay off shoulder of workpiece
6. Remove excess stock on radius of workpiece
    a. Step off shoulder with turning tool
    b. Check with radius gage
7. Mount radius tool
8. Adjust lathe speed
9. Align radius tool with workpiece
10. Machine radius on workpiece
11. Check radius with workpiece with radius gage
    a. Accept workpiece, or
    b. Reject workpiece and/or take corrective action

LEARNING ACTIVITIES

1. Demonstrate mounting workpiece in lathe.
2. Explain lathe tool selection and radius gage selection.
3. Make selection of radius tools.
4. Align radius tool to workpiece.
5. Demonstrate how to use radius gage.

RESOURCES

Johnson. **General Industrial Machine Shop**, pp. 262-266.

EVALUATION

Written Question

Name the tool used to check concave and convex radii.

Answer

The radius gages are used to check concave and convex radii on corners or against shoulders.

DUTY: OPERATING LATHES

TASK: Swing convex or concave radii from compound swivel

PERFORMANCE OBJECTIVE V-TECS 142

STANDARD: Radii must be within a tolerance of ± 1/64" on fraction dimensions, fit a radius gage and/or be in accordance with blueprint specifications.

SOURCE OF STANDARD: Kentucky Writing Team, Incumbent Workers and Instructors.

CONDITIONS FOR PERFORMANCE OF TASK:

Lathe
Work-holding device
Lathe turning tool and holder
Wrenches
Radius gage
Grinder
Layout dye
Scriber
Pocket rule
Blueprint
Workpiece

PERFORMANCE GUIDE

1. Mount workpiece in lathe and set speed
2. Check blueprint for size and location of radius
3. Layout radius location on workpiece
4. Mount tool and holder on compound rest
   a. Center tool on compound rest
   b. Locate point of tool required radius from center of compound swivel point
5. Locate carriage and lock (refer to location of radius)
6. Loosen compound rest bolts enough so compound rest will swivel
7. Start lathe
8. Advance tool with cross feed
9. Touch tool against workpiece
10. Swing compound rest and tool in direction of cut
11. Return to start of arc and advance tool with cross feed approximately 0.020"
12. Swing compound rest slowly by hand for second cut
13. Stop lathe and check radius with gage
14. Adjust tool and carriage, if necessary
15. Continue light cuts until radius completed

LEARNING ACTIVITIES

1. Review how to establish size and location of radius to be cut.
2. Show how to mount tool and holder on compound rest.
3. Demonstrate how compound rest will swivel.
4. Demonstrate making cuts with hand feed.
5. Have a student check radius with gage.

RESOURCES

Johnson. **General Industrial Machine Shop**, p. 257.

EVALUATION

Written Questions

1. Give definition of convex.
2. Give definition of concave.

Answers

1. Convex is having a surface that curves outward like the surface of a sphere.
2. Concave is having a surface that curves inward like the inside section of a sphere, the hollowed-out part.

DUTY: **OPERATING LATHES**

TASK: Chase external threads with the lathe

PERFORMANCE OBJECTIVE V-TECS 113

STANDARD: The threads must be cut to blueprint specifications and fit GO and NO-GO thread ring gages.

SOURCE OF STANDARD: Oberg, et. al. **Machinery's Handbook,** 21st ed., pp. 1915-1916.

CONDITIONS FOR PERFORMANCE OF TASK:

- Lathe
- Lathe centers
- Lathe dog
- Drive plate
- Lathe chuck
- Thread tool
- Thread center tool gage
- Tool holder
- Drill chuck
- Center drill
- GO and NO GO gages
- Screw pitch gage
- Lubricant
- Workpiece
- Blueprint

PERFORMANCE GUIDE

1. Chuck workpiece in lathe
2. Select and set speed (repeat in steps 3-12, as needed)
3. Face and center drill workpiece
4. Secure workpiece between centers
5. Set compound rest to thread specifications (29° or 30°)
6. Mount and align cutter tool bit with gage
7. Set gear box and headstock gears
8. Set lathe speed (slow)
9. Check movement of threading tool for length of work
10. Start lathe
11. Make thread dial selection
12. Cut threads to specifications
    a. Check pitch after first light cut
    b. File burrs during threading operation
    c. Use lubricant
    d. Finish with light cuts
    e. Check fit before completion of cuts
13. Measure thread with GO and NO GO thread ring gage
    a. Accept workpiece, or
    b. Reject workpiece

PERFORMANCE OBJECTIVE V-TECS 113 continued

LEARNING ACTIVITIES

1. Demonstrate how to set up and face workpiece.
2. Demonstrate center drilling workpiece.
3. Explain why compound rest is set at 29°.
4. Discuss thread dial selection.
5. Demonstrate cutting thread to specifications.

RESOURCES

Johnson. **General Industrial Machine Shop,** pp. 296-302.

EVALUATION

Written Questions

1. At what degree is the compound rest set for cutting the screw thread?
2. Explain what is meant by facing the workpiece?
3. What is the purpose of a center gage when cutting threads?

Answers

1. The compound rest is always set at 29° for cutting screw threads.
2. Facing is making the ends of the workpiece square and true.
3. The center gage is used to align threading tool for cutting threads.

DUTY: OPERATING LATHES

TASK: Chase internal threads with lathe

PERFORMANCE OBJECTIVE V-TECS 114

STANDARD: Threads must meet blueprint specifications and fit a GO and NO GO thread plug gage.

SOURCE OF STANDARD: Oberg, et. al. **Machinery's Handbook,** 21st ed., p. 1908.

CONDITIONS FOR PERFORMANCE OF TASK:

Lathe
Lathe chuck
Wrenches
Drill chuck and key
Center drill
Blueprint
Drills
Cutting tool
Boring bar
Single points theading tool
Thread center gage
GO and NO GO thread plug gages
Cutting oil
Telescoping gage
Outside micrometer caliper
Machinist's handbook
Screw pitch gage

PERFORMANCE GUIDE

1. Chuck workpiece in lathe
2. Select and set speed (repeat in steps 3-9, as needed)
3. Face and center drill workpiece
4. Step drill workpiece
    a. Check bore size of hole in machinist's handbook
    b. Drill to within 1/8" of bore size
5. Bore hole to specifications
    a. Counterbore hole thread depth
    b. Chamfer edge of hole
6. Set compound rest to specifications
    a. Compound rest pointing in direction of cut angle
    b. Set on 29° or 30°
7. Mount and square boring bar
8. Make thread dial selection
9. Cut threads to specifications
    a. Check pitch after first light cut
    b. Mark boring bar for length of threads
    c. Use lubricant
    d. Finish with light cuts (cut on same setting occasionally)
    e. Check fit before completion of cuts
    f. Remove chips before checking fit

10. Measure thread with GO and NO GO thread plug gage
    a. Accept workpiece, or
    b. Reject workpiece and/or take corrective action

LEARNING ACTIVITIES

1. Demonstrate different ways to mount workpiece.
2. Demonstrate boring hole to specifications.
3. Discuss compound rest settings.
4. Explain how to make selection on thread dial.
5. Demonstrate cutting thread to size.
6. Demonstrate checking thread with various gages (GO and NO-GO plug gage).

RESOURCES

Johnson. **General Industrial Machine Shop, p. 304.**

EVALUATION

Written Questions

1. Define the term "internal".
2. Define the term "external".
3. For cutting internal threads on a lathe, which direction does the compound rest point?

Answers

1. Internal means inside.
2. External means outside.
3. The compound rest points in the direction of the cutting angle.

DUTY: OPERATING LATHES

TASK: Rechase threads on lathe

PERFORMANCE OBJECTIVE V-TECS 137

STANDARD: Threads must be to blueprint specifications and fit a GO NO-GO thread ring gage.

SOURCE OF STANDARD: Olivo. **Basic Machine Technology**, p. 12.

CONDITIONS FOR PERFORMANCE OF TASK:
- Lathe
- Work-holding device
- Center gage
- Thread tool
- GO NO-GO thread ring gage
- Threaded workpiece
- Blueprint

PERFORMANCE GUIDE

1. Mount workpiece in lathe
2. Mount and align threading tool
   a. Set compound rest on 29° or 30°
   b. Use center gage for alignment
3. Set lathe gear box and gears on headstock
   a. Check blueprint for thread size
   b. Check for RH or LH threads
4. Set lathe speed slow
5. Start lathe
6. Engage half nut and stop lathe after carriage moves a short distance (leave half nut engaged)
7. Adjust cross feed and compound rest until tool matches thread
8. Set cross feed dial and compound rest dial to zero
9. Disengage half nut and move tool to start of thread
10. Take finishing cuts until thread cut to designated dimension
11. Check thread with GO and NO-GO thread ring gage
    a. Accept workpiece, or
    b. Reject workpiece and/or take corrective action

LEARNING ACTIVITIES

1. Demonstrate aligning threading tool with center gage.
2. Explain why compound rest is set at 29°.
3. Demonstrate and explain setting gear box for certain threads.
4. Adjust compound rest and cross-side until tool matches thread.
5. Show how to check threads with GO-NO GO gage.

RESOURCES

Johnson. **General Industrial Machine Shop**, pp. 296-301.

EVALUATION

Written Questions

1. Describe the purpose of the center gage in cutting threads on the lathe.
2. Describe the purpose of the thread pitch gage when cutting threads on the lathe.

Answers

1. The center gage is used to align tool bit at a 90° angle off of work center.
2. The thread pitch gage identifies the number of threads per inch and the pitch of the threads.

DUTY: OPERATING LATHES

TASK: Chase metric threads

PERFORMANCE OBJECTIVE V-TECS 115

STANDARD: Metric thread must be within blueprint specifications and a tolerance of ± 0.1 mm for diameter dimensions and ± 0.5 mm on length dimensions.

SOURCE OF STANDARD: Oberg, et. al. **Machinery's Handbook,** 21st ed., p. 1365.
Krar, et. al. **Technology of Machine Tools,** p. 184.

CONDITIONS FOR PERFORMANCE OF TASK:
Engine lathe
Lathe centers
Dog
Threading tool
Center gage
Metric screw pitch gage
Metric nut or metric thread ring gage
50 T gear
127 T gear
Machinist's handbook
Blueprint
Workpiece

PERFORMANCE GUIDE

1. Mount workpiece between centers on lathe
2. Mount and align thread tool with center gage
    a. Set compound rest
    b. Check dog clearance
3. Set gear box and gears on headstock
    a. Mount 127 T gear on leadscrew
    b. Mount 50 T gear on spindle
    c. Convert thread pitch to centimeters
    d. Use new pitch to set gear box
4. Set lathe speed
5. Take trial cut but do not disengage half nut
6. Check thread with metric screw pitch gage
7. Cut thread to required depth (see machinist's handbook)
8. Check thread with mating nut or metric thread ring gage
    a. Accept workpiece, or
    b. Reject workpiece and/or take corrective action

LEARNING ACTIVITIES

1. Demonstrate mounting workpiece between centers on lathe.
2. Demonstrate how to mount and align threading tool with center gage.
3. Explain setting gear box and gears on headstock.
4. Demonstrate how to make trial cut and not disengage half nut.
5. Check thread with metric screw pitch gage.

PERFORMANCE OBJECTIVE V-TECS 115 continued

RESOURCES

Johnson. **General Industrial Machine Shop**, p. 304.

EVALUATION

Written Questions

1. What should the compound rest be set at when cutting metric "V" threads?
2. What is a thread ring gage?

Answers

1. The compound rest should be set at 29° when cutting metric "V" threads.
2. The thread ring gage is a gage used to check the finish thread.

DUTY: OPERATING LATHES

TASK: Cut Acme threads

PERFORMANCE OBJECTIVE V-TECS 120

STANDARD: Thread must meet blueprint specifications and a class 2 G fit.

SOURCE OF STANDARD: Kibbe, et. al. **Machine Tool Practices,** pp. 526-529.
Oberg, et. al. **Machinery's Handbook,** 21st ed., pp.1323-1336.

CONDITIONS FOR PERFORMANCE OF TASK:
Lathe
Lathe centers
Dog
Acme tool gage
Micrometer caliper
Acme thread ring gage or mating nut
Machinist's handbook
Cutting oil
Blueprint
Workpiece

PERFORMANCE GUIDE

1. Mount workpiece between centers (with lathe dog attached)
2. Check blueprint for thread specifications
3. Machine outside diameter of workpiece to required size
4. Mount and align threading tool with thread gage (set compound rest on 14½°)
5. Set gears on headstock and gearbox for thread
6. Start lathe and take scratch cut
7. Measure threads/inch
8. Set cross slide on zero and advance compound rest 0.005"
9. Check machinist's handbook for thread depth or use formula:

$$TD = \frac{\text{pitch}}{2} + 0.010''$$

10. Cut threads to specifications
    a. With cross slide on zero advance compound rest for cuts
    b. Use cutting oil
    c. Avoid chatter
    d. Advance cross slide for cutting last 0.006"

LEARNING ACTIVITIES

1. Demonstrate mounting work between centers.
2. Discuss what the lathe dog does.
3. Explain how to mount and align threading tool with thread gage (set compound rest on 14 1/2°)
4. Demonstrate starting machine and making scratch cut.
5. Check handbook for thread depth. (Cutting Acme threads)

RESOURCES

Johnson. **General Industrial Machine Shop**, pp. 302-304.

EVALUATION

Written Questions

1. What should the setting on the compound rest be for cutting an Acme thread?
2. How many thousandths should the compound rest advance inward for each cut of Acme threading?

Answers

1. For Acme thread cutting the compound rest is set at 14½°.
2. For each cut on the Acme thread, advance inward .003 for each cut.

DUTY: OPERATING LATHES

TASK: Cut multiple threads

PERFORMANCE OBJECTIVE V-TECS 122

STANDARD: Threads cut must fit a mating workpiece and/or in accordance with blueprint specifications.

SOURCE OF STANDARD: Krar, et. al. **Technology of Machine Tools**, pp. 186-187.

CONDITIONS FOR PERFORMANCE OF TASK:
Lathe
Threading tool
Accurately slotted drive plate
Lathe centers
Lathe dog
Screw pitch gage
Micrometer caliper
Center gage
Gage or mating workpiece
Blueprint

PERFORMANCE GUIDE

1. Mount workpiece between centers on lathe (lathe dog attached)
2. Set gearbox for lead of thread (if lead is ¼ set on 4)
3. Adjust speed to slow
4. Mount thread tool
    a. Set compound rest on 29° or 30°
    b. Line up thread tool with center gage
5. Calculate thread depth (½ depth of 4 threads/inch)
6. Cut thread to depth using compound rest
7. Leave crossfeed handle set and note reading on compound rest
8. Withdraw tool from workpiece using compound rest
9. Revolve workpiece one-half turn in drive plate (leaving dog attached)
    a. Disengaging intermediate gear of end gear train and rotating spindle desired amount
    b. Use thread chasing dial for double start threads with odd numbered lead
10. Cut thread to depth on revolved workpiece as specified
11. Measure workpiece
    a. Accept workpiece as within specifications, or
    b. Reject workpiece and/or take corrective action

LEARNING ACTIVITIES

1. Demonstrate how to mount workpiece in lathe.
2. Lecture on setting gear box.
3. Discuss how to set compound rest to 29°.
4. Demonstrate how to advance in with compound rest for cutting thread.
5. Demonstrate how to revolve workpiece 1/2 turn in face.

RESOURCES

Felker. Machine Shop Technology, p. 258.

EVALUATION

Written Questions

1. When cutting double threads on the lathe, how far apart are the cuts?
2. When cutting triple threads on the lathe, how far apart are the cuts?

Answers

1. When cutting double threads the cuts are 180° apart.
2. When cutting triple threads, the cuts are 120° apart.

DUTY: **OPERATING LATHES**

TASK: Turn or thread long workpieces using follower and steady rest

PERFORMANCE OBJECTIVE V-TECS 144

STANDARD: Workpiece must be within a tolerance of ± 0.005" on decimal dimensions and ± 1/64" on fraction dimensions and/or meet blueprint specifications.

SOURCE OF STANDARD: Giesecke, et. al. **Technical Drawing**, pp. 339, 343.

CONDITIONS FOR PERFORMANCE OF TASK:

- Lathe
- Lathe centers
- Universal lathe chuck
- Lubricant
- Wrenches
- Steady rest
- Follower rest
- Micrometer caliper
- Lathe tool and holder
- Center head
- Layout dye
- Scriber
- Prick punch
- Hammer
- Workpiece
- Blueprint

PERFORMANCE GUIDE

1. Mount chuck on lathe
2. Mount workpiece in chuck
3. Face and center drill workpiece on each end, if possible
4. Adjust steady rest for workpiece centered both ends
    a. Place workpiece between centers
    b. Locate steady rest and clamp to bed (check carriage location)
    c. Raise two lower jaws to touch work and finger tighten clamping bolt
    d. Apply lubricant and lower the upper jaw to work allowing slight clearance
    e. Lock all three jaws
    f. Adjust upper jaw during machining for expansion of workpiece
    g. Use soft shims with jaws for machined surface
5. Adjust steady rest for workpiece without center hole
    a. Chuck one end of workpiece (lightly)
    b. Position steady rest near outer end of workpiece
    c. Scribe two cross center lines using centerhead
    d. Prick punch intersection of two lines
    e. Place dead center in tailstock
    f. Move dead center up to punch mark
    g. Adjust lower jaws to steady rest and lock
    h. Tighten chuck

  - i. Locate steady rest and clamp to bed of lathe (check carriage location)
  - j. Adjust upper jaw, lubricate and lock

6. Mount tool and holder on lathe
7. Turn workpiece to designated dimension
   - a. Keep steady rest lubricated and adjusted
   - b. Check steady rest and carriage clearance
   - c. Use follower rest on long slender shafts
   - d. Mount follower rest on carriage
   - e. Turn end of workpiece for two inches to diameter smaller than finished dimension (workpiece must be two inches longer than finished size)
   - f. Set and adjust tool about 1½" ahead of follower rest jaws
   - g. Machine light cut for two inches on workpiece with jaws disengaged.
   - h. Adjust lower jaw finger tight
   - i. Adjust upper jaw finger tight
   - j. Use lubricant on jaws

LEARNING ACTIVITIES

1. Demonstrate facing and center drilling both ends.
2. Position steady rest and show how to bolt it to lathe bed.
3. Demonstrate setting of the jaws to touch workpiece in steady rest.
4. Show how to adjust and lubricate steady rest.
5. Demonstrate adjusting upper and lower jaws of steady rest.

RESOURCES

Johnson. **General Industrial Machine Shop**, pp. 294-295.

EVALUATION

Written Questions

1. Explain the function of the steady rest.
2. Explain the function of the follower rest.

Answers

1. The steady rest is used for supporting long workpieces when being cut or threaded.
2. The follower rest supports a long workpiece and prevents it from springing away from the tool during operation.

DUTY: OPERATING LATHES

TASK: Machine part with carbide tools

PERFORMANCE OBJECTIVE V-TECS 134

STANDARD: Workpiece must be within a tolerance of ± 0.005" on decimal dimensions and ± 1/64" on fraction dimensions and/or meet blueprint specifications.

SOURCE OF STANDARD: Olivo. **Basic Machine Technology,** p. 12.
Kibbe, et. al. **Machine Tool Practices,** pp. 531-539.

CONDITIONS FOR PERFORMANCE OF TASK:
Lathe
Carbide tool holder
Carbide inserts
Micrometer caliper
Steel rule
Machinist's handbook
Blueprint
Workpiece

PERFORMANCE GUIDE

1. Mount workpiece in lathe
   a. Check workpiece material
   b. Check finish required
2. Select carbide tool and toolholder
   a. Select grade
   b. Select shape
   c. Select size
   d. Check for damage (exchange if necessary)
3. Set lathe speed and feed (check handbook)
4. Mount carbide tool and toolholder
5. Machine workpiece to blueprint specifications

LEARNING ACTIVITIES

1. Demonstrate mounting workpiece in lathe.
2. Discuss selection of tool and tool holder.
3. Set lathe feed and speed according to handbook.
4. Demonstrate mounting carbide tool and toolholder in lathe.
5. Describe machining workpiece to blueprint specifications.

RESOURCES

Johnson. **General Industrial Machine Shop,** pp. 244-246.

EVALUATION

Written Question
What does the cobalt in the carbide tools do to them?

Answer
The cobalt in the tool bits makes them tougher and more wear resistant.

DUTY: **OPERATING LATHES**

TASK: Grind workpiece with tool post grinder

PERFORMANCE OBJECTIVE V-TECS 131

STANDARD: Ground workpiece must meet blueprint specifications with a tolerance of ± 0.0005".

SOURCE OF STANDARD: Olivo. **Basic Machine Technology**, p. 12.

CONDITIONS FOR PERFORMANCE OF TASK:
Lathe
Tool post grinder
Grinding wheel
Diamond point dresser and holder
Vernier micrometer caliper
Work-holding device
Cloth
Blueprint

PERFORMANCE GUIDE

1. Mount tool post grinder
   - a. Check wheel for cracks (replace if cracked)
   - b. Mount wheel guard
   - c. Wear goggles
   - d. Cover v-ways with wet cloth
   - e. Dress and true grinding wheel
2. Mount workpiece on lathe
3. Calculate and set lathe speed (usually 80-100 rpm)
4. Set feed on lathe (0.005" to 0.007")
5. Turn on power of lathe and grinder (work should turn into grinding wheel)
6. Engage workpiece with grinder
7. Engage longitudinal feed and grind workpiece
8. Measure workpiece with micrometer
9. Check for taper and adjust if necessary
10. Continue light cuts
11. Repeat steps 7-9 until workpiece ground to size

LEARNING ACTIVITIES

1. Demonstrate mounting of tool post grinder.
2. Discuss how to set speed and feed of lathe.
3. Explain the running of lathe and the running of grinder.
4. Demonstrate engaging longitudinal feed.
5. Demonstrate grinding workpiece.

RESOURCES

(No information was given in any of the resources available to the writers.)

EVALUATION

Written Questions

1. What should be the lathe speed for grinding with tool post grinder?
2. What should be the lathe feed for grinding with tool post grinder?

Answers

1. When using tool post grinder the lathe speed should be 80-100 rpm.
2. Lathe feed should be .005 to .007 when using tool post grinder.

DUTY: OPERATING LATHES

TASK: Align workpiece on face plate

PERFORMANCE OBJECTIVE V-TECS 111

STANDARD: Workpiece must be aligned to an accuracy of ± 0.001".

SOURCE OF STANDARD: McCarthy and Smith. **Machine Tool Technology,** p. 258.

CONDITIONS FOR PERFORMANCE OF TASKS:
- Lathe
- Dial indicator
- Faceplate
- Chalk
- Clamps
- Straps
- Bolts
- Wrenches
- Soft hammer

PERFORMANCE GUIDE

1. Mount workpiece on faceplate
    - a. Use straps/or bolts
    - b. Use counterbalance weight if necessary
2. Roughly line up workpiece
    - a. Tighten clamps lightly
    - b. Turn lathe by hand
3. Adjust workpiece using chalk or toolholder end
4. Mount indicator
5. Adjust workpiece to required accuracy using indicator
    - a. Tap with soft hammer
    - b. Tighten workpiece securely when aligned within tolerance

LEARNING ACTIVITIES

1. Explain how the workpiece is to be mounted on the face plate.
2. Demonstrate the straps and bolts for mounting on the face plate.
3. Demonstrate roughly lining up the work on face plate.
4. Demonstrate aligning workpiece with dial indicator.
5. Review reading assignment.

RESOURCES

Johnson. **General Industrial Machine Shop,** pp. 266-268.

EVALUATION

Written Questions

1. Name at least one method of mounting the workpiece to the face plate of the lathe.
2. Why is the dial indicator used to align workpiece on the face plate of the lathe?

Answers

1. The workpiece can be mounted to the face plate by using bolts or straps.
2. The dial indicator is the more accurate method of aligning the workpiece.

DUTY: OPERATING LATHES

TASK: Set up turret lathe for operations

PERFORMANCE OBJECTIVE V-TECS 140

STANDARD: Turret lathe must be set up to perform machining operations according to blueprint specifications.

SOURCE OF STANDARD: Heineman and Genevro. **Machine Tools processes Applications,** pp. 216-219.
Walker. **Machining Fundamentals,** p. 201.

CONDITIONS FOR PERFORMANCE OF TASK:
Turret lathe
Toolholders
Cutting tools
Drills
Taps
Reamers
Wrenches
Work-holding device
Machinist's handbook
Operator's handbook
Blueprint
Workpiece

PERFORMANCE GUIDE

1. Study blueprint
   a. Schedule order of operations
   b. Schedule location of cutting tools
2. Secure cutting tools (drills, taps, reamers, etc.)
3. Mount tools in tailstock turret in order of use
4. Mount workpiece in work-holding device
5. Locate and secure tailstock turret
   a. Allow for swing of cutting tools
   b. Allow for indexing turret
6. Set stops on tailstock turret
7. Mount tools in cross-slide
8. Set stops on cross slide
9. Calculate and set lathe speeds and feeds
10. Make trial cuts and adjustments on cutting tools
11. Machine workpiece
12. Measure workpiece and make final adjustments until workpiece is within blueprint specifications

LEARNING ACTIVITIES

1. Explain how to schedule order of operations in turret lathe.
2. Identify the tools and cutter. Explain the order in which they are mounted in the turret lathe.
3. Tell how to set up stops for each operation on turret.
4. Demonstrate making trial cuts.
5. Discuss making final adjustments by specifications.

PERFORMANCE OBJECTIVE V-TECS 140 continued

RESOURCES

Johnson. **General Industrial Machine Shop**, pp. 305-312.

EVALUATION

Written Questions

1. What is the purpose of the turret lathe?
2. What are the two types of turret lathes?

Answers

1. The turret lathe is an indexing-tool machine used to machine identical parts to a close tolerance on a production basis.
2. Two types of turret lathe are ram and saddle.

DUTY: OPERATING LATHES

TASK: Spin workpiece on lathe

PERFORMANCE OBJECTIVE V-TECS 141

STANDARD: Workpiece must meet blueprint specifications and be within a tolerance of ± 1/64".

SOURCE OF STANDARD: Walker. **Machining Fundamentals**, pp. 40-43.

CONDITIONS FOR PERFORMANCE OF TASK:

Lathe
Ball bearing center
Spinning tool post
Chucks
Forms
Annealing equipment
Polishing and buffing supplies
Spinning tools
Measuring instruments
Blueprint
Workpiece

PERFORMANCE GUIDE

1. Set up lathe for spinning
2. Mount metal workpiece
3. Select and set speeds
4. Spin to specifications
    a. Use slow speed until workpiece formed over chuck
    b. Avoid working the tool in only one direction
    c. Use back stick to remove wrinkles
    d. Use torch to anneal hardened workpiece
    e. Lubricate when necessary
    f. Polish or buff (if applicable)

LEARNING ACTIVITIES

1. Demonstrate setting up the lathe for spinning.
2. Explain different methods of mounting work.
3. Demonstrate feed and speed setup.
4. Explain how to spin to specifications.
5. Review reading assignment.

RESOURCES

Johnson. **General Industrial Machine Shop**, pp. 225-229.

EVALUATION

Written Question

Give two methods of mounting work to be spun in the lathe.

Answer

The two mehtods of spinning work are mounting in the chuck and mounting between centers.

MILLING MACHINES

DUTY: OPERATING MILLING MACHINES

TASK: Clean, lubricate and adjust milling machine

PERFORMANCE OBJECTIVE V-TECS 151

STANDARD: Milling machine must be cleaned, lubricated and adjusted to specifications of operator's manual.

SOURCE OF STANDARD: Delmar. **Milling Machine Work**, pp. 10-17.

CONDITIONS FOR PERFORMANCE OF TASK:
Milling machine
Cleaner
Rags
Brush
Lubricants
Wrenches
Screw drivers
Operator's manual

PERFORMANCE GUIDE

1. Start milling machine and check flow gages
2. Stop milling machine and turn off power
3. Clean milling machine and coolant reservoir (use brush for chips)
4. Clean milling machine with rags
5. Lubricate milling machine
    a. Oil at regular intervals
    b. Check frequency in operator's manual
    c. Start at one point and proceed in an orderly method
    d. Avoid over oiling and wipe off excess oil
6. Check oil levels on sight gages and add
7. Check hand operated oiling devices and lubricate milling machine where applicable
8. Locate, clean and fill all oil holes and pockets
9. Check and clean/or replace filters
10. Clean and oil all sliding surfaces
11. Clean and oil exposed screws
12. Check motor lubrication
13. Lubricate driving chain
14. Lubricate ball bearings and other places requiring grease
15. Check table movement by hand and adjust gibs (see manual)
16. Check condition of milling machine and report any needed repairs

LEARNING ACTIVITIES

1. Explain the consequences if milling machine is not maintained according to operator's manual.
2. Describe the procedure to determine if flow gages are operating properly.
3. Demonstrate the method of cleaning and oiling all working parts of machine.
4. Check for worn parts that may need adjusting or replacing.

5. Establish a uniform schedule of preventive maintenance for ALL machinery in the shop.
6. Maintain a record when maintenance should be performed on the milling machine, specifically before and after each operation.

RESOURCES

Repp and McCarthy. **Machine Tool Technology**, pp. 299-381.
Johnson. **General Industrial Machine Shop**, pp. 416-473.

EVALUATION

Written Questions

1. Why should the milling machine be cleaned after each use?
2. How often should the milling machine be checked for oil levels and greasing?
3. Why should the gibs be adjusted in the table and on the column?

Answers

1. Dirt and foreign matter wears out the metal surfaces of the milling machine causing inaccurate machining and irrepairable damage to machine.
2. Everyday or before each use.
3. To remove lost motion or retain accuracy and rigidity when cutting with the machine.

DUTY: OPERATING MILLING MACHINES

TASK: Align mill head to table

PERFORMANCE OBJECTIVE V-TECS 147

STANDARD: The head must be aligned with the table to a tolerance of ± 0.0005".

SOURCE OF STANDARD: Krar, et. al. **Technology of Machine Tools**, p. 277.

CONDITIONS FOR PERFORMANCE OF TASK:
Ram and turret milling machine
Dial indicator and holders
Wrenches
90° extension rod

PERFORMANCE GUIDE

1. Adjust head to zero graduation in both directions
2. Clean table and center under spindle
3. Mount dial indicator on 90° extension rod held in spindle holder
4. Position indicator over front of table
5. Carefully lower spindle until indicator button touches table
6. Lower spindle until dial indicator registers about one half revolution and set on zero
7. Lock spindle
8. Carefully rotate spindle 180° by hand (watch for T-slots)
9. Compare front and back readings
10. Loose locking nuts and adjust head one-half reading difference and lock
11. Recheck setting and make adjustments
12. Raise and rotate spindle 90°
13. Repeat steps 6-11
14. Check readings in both directions
15. Adjust and check until table is aligned with spindle to required tolerance

LEARNING ACTIVITIES

1. Explain the importance of aligning mill head in relation to table.
2. Demonstrate the procedure for adjusting head using the dial indicator.
3. Explain the importance of having a clean table and free from burrs when using dial indicator.
4. Have students clean and smooth table before starting operation.
5. Assign students to complete the task under your supervision.
6. Check head on machine after adjusting to assure that it is securely in place.

RESOURCES

(Information on aligning mill head to table was not available in any of the resources used.)

EVALUATION

Written Questions

1. What happens when the milling head is not aligned properly, vertically or horizontally?
2. How many locations on the milling table should register the exact reading on the dial indicator when spindle is turned 180°?

Answers

1. The cutter will leave a slight concave surface in the workpiece, therefore, if several cuts are taken the workpiece will be uneven.
2. Three places. If table is level it will not change the dial indicator reading.

DUTY: OPERATING MILLING MACHINES

TASK: Square workpiece using table vise

PERFORMANCE OBJECTIVE V-TECS 175

STANDARD: Workpiece must meet blueprint specifications, be square, and to a tolerance of ± 0.005" on decimal dimensions and ± 1/64" on fraction dimensions.

SOURCE OF STANDARD: Olivo. **Basic Machine Technology**, p. 15.

CONDITIONS FOR PERFORMANCE OF TASK:

- Milling machine and accessories
- Table vise
- Shim stock
- Mill cutter
- Workpiece
- Soft faced hammer
- Square
- Micrometer caliper
- Dial indicator
- Blueprint

PERFORMANCE GUIDE

1. Identify workpiece material
2. Mount and position vise (use dial indicator)
3. Select and mount cutter
4. Select and set up speed and feed
5. Mount and align workpiece to cutter
6. Make first cut
7. Turn off machine, rotate workpiece to place finished side against fixed vise jaw, and secure
8. Make second cut to depth (allow material for opposite side)
9. Measure for accuracy and place workpiece so that second finished surface (steps 7 and 8) is on the bottom of the vise
10. Make third cut
11. Turn off machine, measure for accuracy, and rotate workpiece
12. Cut remaining side to specifications

LEARNING ACTIVITIES

1. Explain the importance of a properly mounted and indicated vise for accuracy of workpiece.
2. Describe the procedure for making first cut to acquire a starting point or a square side.
3. Check for proper feed and speed.
4. Explain the consequences if workpiece is not secured properly in vise.
5. Emphasize the use of cutting fluid in all milling operations.
6. Assign students to mill to specifications.

RESOURCES

Repp and McCarthy. **Machine Tool Technology**, pp. 316-317.
Johnson. **General Industrial Machine Shop**, p. 451.

EVALUATION

Written Questions

1. Why is it essential to place the first finished side of workpiece against the fixed jaw of vise on the milling machine?
2. After making second cut, what is placed in vise under workpiece to keep it off the bottom of vise?

Answers

1. The fixed jaw has been indicated square and true to head and table of milling machine, therefore there is less room for inaccuracy.
2. Two identical strips of metal called parallels to allow only a small area of workpiece to touch vise for ease in checking for flatness and squareness.

DUTY: OPERATING MILLING MACHINES

TASK: Align milling machine attachments

PERFORMANCE OBJECTIVE V-TECS 148

STANDARD: Attachment must be aligned to milling machine table within a tolerance of 0.001" runout in 4".

SOURCE OF STANDARD: Krar, et. al. **Technology of Machine Tools**, p. 222.

CONDITIONS FOR PERFORMANCE OF TASK:

Milling machine
90° milling attachment
Extended draw bar
Magnetic base and post
Dial indicator
Plastic mallet
Hex wrench
Mill wrench

PERFORMANCE GUIDE

1. Replace draw bar with extended draw bar
2. Drop quill approximately 3 inches and lock
3. Insert 90° attachment driver in quill and tighten draw bar securely, being careful to align key with keyway
4. Position indicating surface parallel with table movement
5. Snug the two housing clamp bolts
6. Attach magnetic base with dial indicator
7. Indicate the 90° milling attachment for parallel alignment with table movement
8. Secure housing clamp bolts
9. Recheck step 7 for accuracy
10. Repeat steps 7-9 until alignment is within tolerance

LEARNING ACTIVITIES

1. Explain how to determine the correct draw bar to be used in the 90° milling attachment.
2. Demonstrate the setup procedure for attaching and aligning the head on the milling machine with dial indicator.
3. Explain the results if the 90° attachment is not clamped in the correct position, or if forced on the draw bar.
4. Check attachment and machine for dirt or metal shavings, clean both surfaces so they will seat properly.
5. Assign students to perform indicating procedure after demonstration.

RESOURCES

Repp and McCarthy. **Machine Tool Technology**, pp. 313-318.
Johnson. **General Industrial Machine Shop**, pp. 425-433.

EVALUATION

Written Questions

1. What is the most common instrument used in aligning the head or vertical attachments on the milling machine?
2. Why is it essential that the attachment be aligned to a zero tolerance in parallel with milling table?

Answers

1. Dial indicator
2. Work performed in the milling machine will not be accurate if head is not parallel to table.

DUTY: OPERATING MILLING MACHINES

TASK: Align milling machine fixtures with indicator

PERFORMANCE OBJECTIVE V-TECS 149

STANDARD: The fixture must be aligned on the milling machine tool to within ± .001" total runout.

SOURCE OF STANDARD: Kentucky Writing Team, Incumbent Workers and Instructors.

CONDITIONS FOR PERFORMANCE OF TASK:
Vise
Clamping bolts
Wrench
Dial indicator
Plastic mallet
Square

PERFORMANCE GUIDE

1. Clean and place vise on bed
2. Align vise by sight
3. Fasten vise to bed with clamping bolts (do not tighten)
4. Locate dial indicator in mill spindle or magnetic tool holder
5. Indicate the fixed vise jaw
   a. For perpendicular alignment use square against column before using dial indicator
   b. Use longitudinal feed or cross feed as required
6. Check vise jaw at each end of jaw
7. Tap vise one-half difference of readings for correction
8. Repeat steps 5-7 until vise aligned
9. Secure clamp bolts
10. Recheck with indicator (if vise has moved repeat steps 5-10 until vise is aligned)

LEARNING ACTIVITIES

1. Explain the use of the dial indicator when aligning milling machine fixtures.
2. Demonstrate setup of dial indicator and the importance of indicating fixed jaw of the vise.
3. Check for dirt or other foreign objects on vise, mill table or in the "T" slots of machine.
4. Describe the procedure for moving table back and forth in parallel with stationary indicator for required accuracy in alignment.
5. Have student practice this task repeatedly as it is used in every task performed on the milling machine.

RESOURCES

Johnson. **General Industrial Machine Shop**, p. 428.
Repp and McCarthy. **Machine Tool Technology**, p. 338.

EVALUATION

Written Questions

1. How is the dial indicator used in aligning fixtures on the milling machine?
2. What part of vise should be indicated when setting up vise on milling machine?

Answers

1. To align fixtures on the milling machine, they are moved longitudinally along fixed jaw of vise to check for accuracy using the graduated dial on the dial indicator. (The dial is graduated in .001 increments.)
2. Fixed jaw.

DUTY: OPERATING MILLING MACHINES

TASK: Align workpiece mounted on machine table

PERFORMANCE OBJECTIVE V-TECS 146

STANDARD: The workpiece must be aligned to a tolerance of 0.001" total indicator run out.

SOURCE OF STANDARD: Delmar. Milling Machine Work, pp. 93-94, 169.

CONDITIONS FOR PERFORMANCE OF TASK:

- Milling machine
- Straps
- Clamps
- Bolts
- Dial indicator and holder
- Cardboard
- Blocks
- Parallels
- Soft hammer
- Wrenches
- Blueprint
- Workpiece

PERFORMANCE GUIDE

1. Clean out slots on milling machine table
2. Study blueprint
    a. Note surface to be machined
    b. Note type of cutter required
3. Place workpiece on machine table
    a. Use cardboard under workpiece
    b. Center workpiece longitudinally on table
    c. Locate workpiece according to machining operation
4. Select clamps, blocks, and bolts
5. Clamp workpiece down lightly in rough position
6. Clamp indicator assembly on arbor
7. Adjust indicator contact point toward workpiece surface
8. Move table and workpiece next to indicator contact point
9. Move table longitudinally
10. Adjust workpiece to correct line up with indicator
11. Move table and workpiece in contact with indicator contact point
12. Adjust table against indicator about 0.010"
13. Move table longitudinally the length of the workpiece
14. Observe total movement of indicator at each end of workpiece
15. Adjust workpiece
    a. Adjust workpiece one half difference of end readings
    b. Tap lightly with soft hammer
16. Check workpiece with indicator for runout
17. Repeat steps 13-16 until workpiece is within designated tolerance

LEARNING ACTIVITIES

1. Explain the importance of a clean, dirt-free milling table.
2. Describe the proper clamps and hold-downs for mounting workpiece to table.
3. Demonstrate the aligning procedure with dial indicator.
4. Discuss the importance of exercising care when using the dial indicator.
5. Have student repeat the procedure until workpiece is properly aligned.

RESOURCES

Repp and McCarthy. **Machine Tool Technology**, pp. 338-339.
Johnson. **General Industrial Machine Shop**, pp. 425-428.

EVALUATION

Written Question

Explain the use of the dial indicator in aligning the workpiece on the milling machine.

Answer

The dial indicator is graduated in .001 inches and set on one end of workpiece. By moving longitudinally, the indicator travels from end to end and shows amount of runout of workpiece.

DUTY: OPERATING MILLING MACHINES

TASK: Drill holes with milling machine

PERFORMANCE OBJECTIVE V-TECS 153

STANDARD: Tolerance of holes to be ± 1/64" on fraction dimensions and ± 0.005" on decimal dimensions.

SOURCE OF STANDARD: Oberg, et. al. **Machinery's Handbook,** 21st ed., p. 1669.
Olivo. **Basic Machine Technology,** p. 15.

CONDITIONS FOR PERFORMANCE OF TASK:
Milling machine
Work-holding device
Plastic mallet
Dial indicator
Edgefinder
Hole gage
Wiggler
Combination drill and countersink
Drills
Drill chuck
Micrometer caliper
Steel
Rule
Vernier calipers
Arbor
Adaptor sleeve
Machinist's handbook
Workpiece
Blueprint

PERFORMANCE GUIDE

1. Mount and align holding device
   a. Use indicator
   b. Use edgefinder
2. Secure workpiece in holding device
3. Mount arbor and drill chuck
4. Align over first hole to be drilled
5. Set machine speed (see machinist's handbook)
6. Center drill workpiece (use coolant as required in drilling)
7. Drill first hole
   a. Note depth on blueprint
   b. Note graduated dial reading for reference in drilling similar holes
   c. When using power feed see machinist's handbook for rate of feed
8. Use mill graduated dials to step over and drill subsequent holes to specifications
9. Measure workpiece
   a. Check hole sizes
   b. Check hole location
   c. Accept workpiece as within tolerances, or
   d. Reject workpiece and/or take corrective action

PERFORMANCE OBJECTIVE V-TECS 153 continued

LEARNING ACTIVITIES

1. Explain the procedure for aligning workholding device on milling machine table with dial indicator.
2. Explain the use of the edgefinder in locating center of workpiece or the locations of holes.
3. Emphasize the use of proper coolant and the adverse effects if not used when milling.
4. Discuss the purpose of center-drilling before drilling holes.
5. Demonstrate the using of the graduated dials for stepping over to find hole centers on workpiece.
6. Check for correct speeds and feeds if automatic feed is used.
7. Have student perform each step from aligning vise to drilling and finishing holes in workpiece.

RESOURCES

Johnson. **General Industrial Machine Shop,** Unit 85.
Repp and McCarthy. **Machine Tool Technology,** Units 81 and 82.

EVALUATION

Written Questions

1. Why is an edgefinder used in the drilling operation on the milling machine?
2. How are hole distances found when drilling more than one hole on the milling machine?

Answers

1. To determine the exact location from the edge of workpiece to center of hole.
2. By using the graduated dials to move over to next hole with complete accuracy.

DUTY: OPERATING MILLING MACHINES

TASK: Ream holes on mill

PERFORMANCE OBJECTIVE V-TECS 174

STANDARD: Workpiece must meet blueprint specifications and to a tolerance of $^{+0.0005''}_{-0.0000''}$ on reamed holes and ± 1/64" on fraction dimensions.

SOURCE OF STANDARD: Oberg, et. al. **Machinery's Handbook,** 21st ed., pp. 1785-1787.
Olivo. **Basic Machine Technology**, p. 15.

CONDITIONS FOR PERFORMANCE OF TASK:
Milling machine
Layed out workpiece
Work-holding device
Arbors and adaptors
Drills
Drill chuck
Collets
Reamers
Center drill
Hole gage
Vernier micrometer caliper
Steel rule
Dial indicator
Machinist's handbook
Lubricant
Blueprint

PERFORMANCE GUIDE

1. Mount and align work-holding device with dial indicator
2. Mount workpiece in work-holding device
3. Mount drill chuck and center drill in milling machine spindle
4. Align workpiece under center drill
5. Calculate feed and set speed (repeating, as necessary)
6. Center drill workpiece
7. Drill hole undersize for reaming
8. Ream hole to specifications
   a. Use lubricant as required
   b. Set speed one-half drilling speed
9. Measure drilled hole
   a. Accept workpiece, or
   b. Reject workpiece and/or take corrective action

LEARNING ACTIVITIES

1. Explain the importance of proper mounting and aligning of workholding devices on milling machines.
2. Describe the procedure for using the center drill and why it is critical in obtaining an accurate starting point in workpiece.

3. Explain how to find the correct drill size for the reaming or finished size of hole.
4. Demonstrate the different speeds used for drilling operations and reaming operations.
5. Emphasize the use of proper cutting fluid and the results if it is not properly used.
6. Have students drill and ream to specifications.

RESOURCES

Johnson. **General Industrial Machine Shop,** pp. 468-473.
Repp and McCarthy. **Machine Tool Technology,** pp. 166-171.

EVALUATION

Written Questions

1. Why is it necessary to drill the hole undersized when reaming on the milling machine?
2. Why is the drilling speed reduced by at least half when reaming the hole to size on the milling machine?

Answers

1. To allow enough metal to be removed for finishing to specified size of reamer.
2. To reduce excessive overheating and wear on reamer.

DUTY: OPERATING MILLING MACHINES

TASK: Mill work with end mill

PERFORMANCE OBJECTIVE V-TECS 172

STANDARD: Workpiece msut meet blueprint specifications and be within a tolerance of ± 0.005" on decimal dimensions and ± 1/64" on fractions dimensions.

SOURCE OF STANDARD: Oberg, et. al. **Machinery's Handbook,** 21st ed., pp. 1771-1778.
Olivo. **Basic Machine Technology,** p. 15.

CONDITIONS FOR PERFORMANCE OF TASK:
- Milling machine
- Work-holding device
- End mill cutters
- Arbors and adaptors
- Dial indicator
- Micrometer caliper
- Depth micrometer
- Steel rule
- Machinist's handbook
- Blueprint
- Workpiece

PERFORMANCE GUIDE

1. Mount workpiece and work-holding device on milling machine table
   a. Align with dial indicator
   b. Allow overhang of workpiece for cutter clearance
2. Select and mount cutter in milling machine
   a. Calculate and set speed and feed
   b. Refer to machinist's handbook
   c. Set table trip dogs
3. Start mill and touch off workpiece
4. Locate workpiece and set depth of cut
5. Lock table and knee and machine workpiece
6. Measure workpiece and repeat cuts until workpiece machined to specifications

LEARNING ACTIVITIES

1. Explain the clamping procedure for mounting workpiece to hang over edge of milling table for cutter clearance.
2. Demonstrate the art of indicating workpiece for parallel to work table.
3. Check for correct feed and speed for cutter being used.
4. Position table stops for automatic cut off of feed when cut is finished.
5. Assign student to machine to specifications.

RESOURCES

Repp and McCarthy. **Machine Tool Technology,** p. 326.
Johnson. **General Industrial Machine Shop,** p. 437.

EVALUATION

Written Questions

1. When cutting workpiece with end mill, should the end mill be fed into or away from the workpiece? Explain.
2. Which is the stronger tooth construction, the two lipped or the four lipped end mill?

Answers

1. The mill cutter should always be fed into workpiece in direction of cutter rotation. If fed in opposite direction workpiece is going away from cutter, causing a climbing effect which can cause cutter to grab or dig into workpiece causing cutter to break, damage workpiece, and may cause serious injury to operator.
2. The two lipped end mill is stronger as the body is thicker.

DUTY: OPERATING MILLING MACHINES

TASK: Locate work with center finder

PERFORMANCE OBJECTIVE V-TECS 159

STANDARD: Workpiece must be located within blueprint specifications to a tolerance of ± 0.001".

SOURCE OF STANDARD: Kentucky Writing Team, Incumbent Workers and Instructors.

CONDITIONS FOR PERFORMANCE OF TASK:

Milling machine
Work-holding device
Center punched workpiece
Centerfinder
Dial indicator and holder
Blueprint
Workpiece

PERFORMANCE GUIDE

1. Mount work-holding device on mill table
2. Align work-holding device with dial indicator
3. Mount center punched workpiece in work-holding device
4. Place centerfinder in spindle of mill
5. Align centerfinder with center punch on workpiece
    a. Light touch point of center finder in punch mark
    b. Rotate spindle by hand
    c. Check runout and adjust table
    d. Mount dial indicator with pointer against centerfinder
    e. Repeat steps b and c until table aligned within tolerance

LEARNING ACTIVITIES

1. Describe proper mounting of workholding device on milling machine and the importance of proper aligning.
2. Explain and demonstrate the method of checking the centers visually for an approximate alignment.
3. Explain the function of the center finder and how it is used.
4. Demonstrate the setup of center finder in spindle and on workpiece.
5. Explain how the dial indicator is used to assure the accuracy needed in this operation.

RESOURCES

Johnson. **General Industrial Machine Shop**, pp. 470-471.

EVALUATION

Written Questions

1. How are the holes located on workpiece on the milling machine?
2. What instrument is used, along with the centerfinder, to assure accurate centers on workpiece in the milling machine?

PERFORMANCE OBJECTIVE V-TECS 159 continued

Answers

1. Centerfinder, or wiggler
2. Dial indicator

DUTY: OPERATING MILLING MACHINES

TASK: Locate work with edge finder

PERFORMANCE OBJECTIVE V-TECS 160

STANDARD: Workpiece must be located within blueprint specifications and within a tolerance of ± 0.001".

SOURCE OF STANDARD: Krar, et. al. **Technology of Machine Tools**, pp. 301-302.

CONDITIONS FOR PERFORMANCE OF TASK:
Milling machine
Work-holding device
Dial indicator and holder
Edgefinder
Workpiece
Blueprint

PERFORMANCE GUIDE

1. Mount work-holding device on mill table
2. Align work-holding device with dial indicator
3. Mount workpiece in work-holding device
4. Mount dial indicator in machine spindle
5. Center edge of workpiece approximately under spindle
6. Hold edgefinder against edge of workpiece (or clamp)
7. Adjust indicator holder so indicator point touches one edge of slot in edgefinder
8. Adjust indicator to register 0.010" to 0.020"
9. Rotate spindle back and forth slightly by hand to locate highest reading
10. Set indicator to zero
11. Turn spindle one-half turn and stop at highest reading on opposite side
12. Move handwheel one half difference in readings
13. Repeat steps 9-12 until readings are the same or within tolerance

LEARNING ACTIVITIES

1. Explain the mounting and indicating procedure of workholding devise on milling machine table for parallel accuracy.
2. Check the type of edgefinder to be used.
3. Demonstrate the procedure of positioning the edgefinder against workpiece to find true edge.
4. Allow student to manually set up workpiece with edgefinder under your supervision as it will take several trials before he or she can master the art.
5. Check workpiece after student has concluded this operation before any machine work is started to assure accuracy.

RESOURCES

Repp and McCarthy. **Machine Tool Technology**, p. 344.

EVALUATION

Written Questions

1. How do you know when the edgefinder locates the true center of the workpiece on the milling machine table?
2. How far does the handwheel travel when indicator is moved 180° by rotating the spindle of the milling machine?

Answers

1. When the dial indicator attached in the spindle is rotated 180° and the reading on the dial is the same on either side.
2. One half the reading on the dial indicator.

DUTY: OPERATING MILLING MACHINES

TASK: Machine work with vertical attachment

PERFORMANCE OBJECTIVE V-TECS 166

STANDARD: Workpiece must be within a tolerance of ± 0.003" on decimal dimensions, ± 1/64" on fraction dimensions, ± 1° on angular dimensions and/or within blueprint specifications.

SOURCE OF STANDARD: Heineman and Genevro. **Machine Tools Processes and Applications,** p. 15.

CONDITIONS FOR PERFORMANCE OF TASK:

Horizontal milling machine
Vertical attachment
Milling cutters
Arbors
Adaptors
Work-holding device
Dial indicator
Vernier bevel protractor
Steel rule
Square
Machinist's handbook
Micrometer caliper
Blueprint
Workpiece

PERFORMANCE GUIDE

1. Attach vertical attachment to milling machine
2. Adjust attachment to required angle
   a. Check blueprint
   b. Use graduations on attachment
   c. Check with square and dial indicator, or
   d. Check with vernier bevel protractor
3. Mount work-holding device on mill table
4. Mount workpiece in work-holding device and align
5. Mount cutter in attachment with arbor or adaptor
6. Set milling machine speed, feed, and depth of cut
7. Machine workpiece to specifications

LEARNING ACTIVITIES

1. Explain the uses of vertical attachment on the milling machine.
2. Set up attachment on correct angle using appropriate instruments for aligning.
3. Describe the correct workholding device for holding workpiece to milling machine table.
4. Select the proper feed and speed for machining.
5. Assign students to machine workpiece to blueprint tolerances.

RESOURCES

Repp and McCarthy. **Machine Tool Technology**, pp. 315-316.
Johnson. **General Industrial Machine Shop**, p. 432.

EVALUATION

Written Questions

1. What is the proper way of setting up a vertical attachment to the milling machine?
2. Give three ways to determine the correct angle on the vertical attachment.

Answers

1. Bolt the vertical attachment directly to the column of the horizontal milling machine. The horizontal spindle will drive the vertical head spindle.
2. a. By the graduated dial on the vertical attachment
   b. Square and indicator
   c. Vernier bevel protractor

DUTY: OPERATING MILLING MACHINES

TASK: Machine external straight keyway with mill

PERFORMANCE OBJECTIVE V-TECS 161

STANDARD: Accuracy for cutting the external keyway must be: depth +0.005", -0.005" length ± 1/64", and center line position ± 0.005" and/or blueprint specifications.

SOURCE OF STANDARD: Delmar. **Milling Machine Work**, pp. 205-210.

CONDITIONS FOR PERFORMANCE OF TASK:

Milling machine
Mill vise
Milling cutter
Micrometer caliper
Combination square
Layout dye
Scriber
Steel rule
Paper feeler
Dial indicator
Machinist's handbook
Style B mill arbor
Key
File
Blueprint
Workpiece

PERFORMANCE GUIDE

1. Mount and align vise to table with dial indicator
2. Select and mount cutter
   a. Check for size on blueprint
   b. Use style B arbor
3. Set machine speed
4. Mount workpiece in vise
5. Set center line of cutter on center line of shaft, close to holding device
6. Center cutter with combination square against each side of work and measure with steel rule
7. Layout length of keyway
8. Turn mill on and raise table until cutter touches (long) paper feeler held between cutter and workpiece
9. Set vertical dial on zero
10. Raise table 0.005"
11. Stop cutter and lower knee about 0.020"
12. Cut on workpiece should be centered on cutter
13. Determine depth of keyway from machinist's handbook
14. Machine keyway to within approximately 0.020" of full depth
15. Stop mill and deburr workpiece
16. Insert key and measure size of workpiece plus key
17. Calculate final depth
18. Machine keyway to specified dimensions

LEARNING ACTIVITIES

1. Explain the procedure for mounting and indicating vise on milling table and the importance of this operation.
2. Describe the steps taken to assure the centering of cutter to shaft, by above method.
3. Demonstrate the use of an edgefinder for centering cutter and the proper way of finding the correct depth of keyway.
4. Check machine for desired feeds and speeds for specific cutter size and metal to be used.
5. Explain the consequences if cutter is not cutting in correct direction in workpiece.
6. Have student machine keyway to exact specifications.

RESOURCES

Repp and McCarthy. **Machine Tool Technology**, pp. 344-345.
Johnson. **General Industrial Machine Shop**, p. 472.

EVALUATION

Written Questions

1. How is the centerline of workpiece located for cutting external keyway in the milling machine?
2. How is the depth of a keyway determined in a milling machine?

Answers

1. By using an edgefinder or placing a piece of paper between cutter and workpiece.
2. The standard depth of a keyway is one half the width of keystock used in the keyway. (For 1/2" key depth of keyway, it should be 1/4" deep.)

DUTY: OPERATING MILLING MACHINES

TASK: Machine work mounted on V-blocks

PERFORMANCE OBJECTIVE V-TECS 165

STANDARD: The workpiece must be machined within a tolerance of ± 0.001" on decimal dimensions and ± 1/64" on fraction dimensions and/or to blueprint specifications.

SOURCE OF STANDARD: Delmar. **Milling Machine Work**, p. 97.
Olivo. **Basic Machine Technology**, p. 15.

CONDITIONS FOR PERFORMANCE OF TASK:
- Milling machine
- V-blocks
- Step blocks
- Strap clamps
- T-bolts
- Copper strips
- Micrometer caliper
- Steel rule
- Workpiece
- Blueprint

PERFORMANCE GUIDE

1. Clean out slots of milling machine
2. Wipe off table of milling machine
3. Clean V-blocks
4. Mount V-blocks on table placing tongues of V-blocks in T-slots.
5. Clamp workpiece to milling machine table
    - a. Select two flat straps or clamps
    - b. Clamp workpiece with strap clamp T-bolts and step block
    - c. Use copper strip to protect workpiece
    - d. Keep straps level
    - e. Keep clamping pressure close to workpiece
6. Set machine speed and feed
7. Machine workpiece to blueprint specifications

RESOURCES

Repp and McCarthy. **Machine Tool Technology**, pp. 298-381.
Johnson. **General Industrial Machine Shop**, pp. 417-474.

EVALUATION

Written Questions

1. List the five steps in proper sequence for setting up a workpiece in V-blocks on the milling machine.
2. Why should the clamping device be set as close to the workpiece as possible when milling?

Answers

1. Clean table
   Clean T-slots
   Wipe all accessories or attachments clean and free of dirt and grease
   Mount V-blocks in T-slots in milling table
   Use the proper clamps and step blocks to keep clamps level with workpiece
2. Clamps that are not secured as close to the work piece as possible may allow the workpiece to move and cause inaccuracy in the measurements.

DUTY: **OPERATING MILLING MACHINES**

TASK: Flycut flat surface on mill

PERFORMANCE OBJECTIVE V-TECS 155

STANDARD: Workpiece must be flycut to a tolerance of ± .003" on decimal dimensions and ± 1/64" on fraction dimensions and/or to blueprint specifications.

SOURCE OF STANDARD: Delmar. **Milling Machine Work**, p. 120.

CONDITIONS FOR PERFORMANCE OF TASK:

- Milling machine
- Vise
- Fly cutter
- Cutting tool
- Dial indicator
- Micrometer caliper
- Steel rule
- Parallels
- Blueprint
- Workpiece

PERFORMANCE GUIDE

1. Identify workpiece material
2. Mount and align vise using dial indicator
3. Secure workpiece in vise
4. Select and mount flycutter
5. Select and set speed and feed
6. Align cutter to workpiece, touch off, and set depth of cut
7. Make preliminary cuts
8. Remove workpiece, deburr, rotate workpiece 180°, and secure in vise on parallels
9. Touch off and set cutter to secondary cut depth
10. Set depth of cut to blueprint specifications
11. Make finish cut
12. Measure for accuracy of cut

LEARNING ACTIVITIES

1. Check type of material to be machined.
2. Explain the aligning of vise to assure accuracy of workpiece.
3. Describe the use of parallels in the vise and the consequences if not used properly.
4. Demonstrate the touching-off on workpiece and explain why this procedure is used in almost every milling operation.
5. Discuss the importance of de-burring workpiece before it is turned 180° in the vise.
6. Have student machine to specifications, checking between cuts for the correct tolerance.

RESOURCES

Johnson. **General Industrial Machine Shop**, p. 440.
Repp and McCarthy. **Machine Tool Technology**, pp. 328-329.

EVALUATION

Written Questions

1. Describe a fly cutter on the milling machine?
2. What are the advantages of using a fly cutter in the milling machine?

Answers

1. A fly cutter is a tool consisting of one or more single-point tool bits or cutters mounted in a bar or cylinder which is attached to the spindle of the milling machine.
2. A fly cutter can do several operations: mill flat surfaces; cut grooves; cut holes through thin metal; and, since each tool is adjustable individually, holes of several diameters can be bored simultaneously.

DUTY: OPERATING MILLING MACHINES

TASK: Flycut formed shape on mill

PERFORMANCE OBJECTIVE V-TECS 156

STANDARD: Workpiece must meet blueprint specifications and fit a template or gage.

SOURCE OF STANDARD: Delmar. **Milling Machine Work**, p. 120.

CONDITIONS FOR PERFORMANCE OF TASK:
Milling machine
Work-holding device
Fly cutter adaptor
Ground shaped cutting tool
Dial indicator
Steel rule
Micrometer caliper
Template or gage
Machinist's handbook
Blueprint
Workpiece

PERFORMANCE GUIDE

1. Identify workpiece material
2. Mount and align work-holding device with dial indicator
3. Secure workpiece in work-holding device
4. Select and mount flycutter and tool
5. Select and set speed and feed
6. Align cutter to workpiece, touch off, and set approximate depth of cut
7. Make preliminary cut
8. Check workpiece with template or gage
9. Adjust if necessary
10. Set depth of cut to blueprint specifications
11. Make finish cut
12. Continue other cuts, if required, following steps 6-11
13. Measure workpiece
    a. Accept workpiece, or
    b. Reject workpiece and/or take corrective action

LEARNING ACTIVITIES

1. Check material to be machined.
2. Explain the procedure and the importance of securing and aligning of vise on workholding device on milling machine.
3. Describe the functions of a fly cutter and the proper way to use it.
4. Check feeds and speeds for proper machining of workpiece.
5. Discuss the use of the template and why it is used.
6. Have student make preliminary cut, measure, make adjustments and finish to template or gage.

PERFORMANCE OBJECTIVE V-TECS 156 continued

RESOURCES

Johnson. **General Industrial Machine Shop**, p. 440.
Repp and McCarthy. **Machine Tool Technology**, pp. 328-329.

EVALUATION

Written Questions

1. How are formed shapes cut on the milling machine?
2. How is the workpiece checked to assure that it is within tolerance?

Answers

1. With fly cutter having a ground shaped cutting tool, called a forming tool.
2. With templates, gages, or optical comparator

DUTY: OPERATING MILLING MACHINES

TASK: Form mill workpiece

PERFORMANCE OBJECTIVE V-TECS 157

STANDARD: Workpiece must meet blueprint specifications and fit radius gage or template.

SOURCE OF STANDARD: Delmar. **Milling Machine Work**, p. 119.

CONDITIONS FOR PERFORMANCE OF TASK:
Milling machine
Work-holding device
Form milling cutter
Radius gages
Micrometer caliper
Steel rule
Dial indicator and holder
References
Template
Blueprint
Workpiece

PERFORMANCE GUIDE

1. Identify material of workpiece
2. Mount and align work-holding device
3. Select and mount form ground milling cutter
4. Secure and align workpiece in work-holding device
5. Select and set speed and feed
6. Touch off and set depth of cut allowing for finish cut
7. Make preliminary cut
8. Check and measure workpiece configuration
9. Make cutting adjustments and cut to blueprint specifications

LEARNING ACTIVITIES

1. Describe the proper use of indicator for aligning workholding device.
2. Emphasize the importance of using the correct cutter to form mill workpiece.
3. Check for correct speed and feed for material being used for project being milled.
4. Explain the correct method of aligning cutter on workpiece to obtain desired shape of workpiece.
5. Assign student to make any adjustment after first cut, then finish to specifications.

RESOURCES

Repp and McCarthy. **Machine Tool Technology**, pp. 327-328.
Johnson. **General Industrial Machine Shop**, p. 436.

EVALUATION

Written Questions

1. What is meant by form milling?
2. Name at least three items that form cutters are essential in their manufacturing process.

Answers

1. Form milling is the shaping of workpiece by means of a cutter ground to the shape or contour desired in finished product.
2. Form cutters are used extensively in the manufacturing of taps, reamers, milling cutters and gears.

DUTY: OPERATING MILLING MACHINES

TASK: Bore holes to tolerance with milling machine

PERFORMANCE OBJECTIVE V-TECS 150

STANDARD: Bored hole must be within a tolerance of ± 1/64" on fraction dimension, and ± 0.002" on decimal dimensions, and/or within blueprint specifications.

SOURCE OF STANDARD: Krar, et. al. **Technology of Machine Tools**, pp. 297-298.

CONDITIONS FOR PERFORMANCE OF TASK:

Vertical mill
Holding fixtures
Dividers
Rule
Layout dye
Mill wiggler
Drill chuck
Combination drill and countersink
Drills
Plug gage
Micrometer calipers
Telescope gage or inside micrometer
Workpiece
Center punch
Hammer
Steel rule
Adjustable boring head
Boring bar
Blueprint

PERFORMANCE GUIDE

1. Lay out hole location and center punch
2. Mount workpiece on milling machine table
3. Mount wiggler in spindle
4. Center hole under spindle with wiggler
5. Lock table
6. Select and set speeds and feeds
7. Centerdrill workpiece
8. Drill pilot hole
9. Drill hole to allow for clearance in boring
10. Select boring head and boring tool
11. Mount offset boring head and tool in spindle
12. Determine amount of tool movement by adjustment screw
13. Set milling machine speed and feed
14. Set cutter for light cut on workpiece
15. Start milling machine and bore workpiece
16. Measure bored hole and adjust tool
17. Continue steps 15-16 until workpiece bored to designated dimension

PERFORMANCE OBJECTIVE V-TECS 150 continued

LEARNING ACTIVITIES

1. Explain the method of mounting and aligning workpiece in milling machine using dial indicator.
2. Describe the purpose of the wiggler in centering workpiece.
3. Explain the meaning of the pilot hole and the amount of material to leave for boring.
4. Demonstrate the mounting and setting of the offset boring head.
5. Have students bore hole to specifications.

RESOURCES

Johnson. **General Industrial Machine Shop,** pp. 468-473.
Repp and McCarthy. **Machine Tool Technology,** pp. 314-315.

EVALUATION

Written Questions

1. List the procedure for boring holes on the milling machine, after the workpiece has been indicated and secured in workholding device.
2. What increments is the dial on the offset boring head divided?

Answers

1.
   a. Mount wiggler in spindle.
   b. Center spindle of mill over pre-punched hole with wiggler.
   c. Center drill workpiece.
   d. Drill pilot hole.
   e. Drill hole 1/16" to 1/8" smaller than finished size.
   f. Mount offset boring head and bore trial cut, check hole for size.
   g. Set dial on boring head, using adjustment screw to finish, bore to dimesions.
2. In .001 inch.

DUTY: OPERATING MILLING MACHINES

TASK: Jig bore on a milling machine

PERFORMANCE OBJECTIVE V-TECS 158

STANDARD: Workpiece must be within a tolerance of ± 0.001" on decimal dimensions and ± 1/64" on fraction dimensions and meet blueprint specifications.

SOURCE OF STANDARD: Krar, et. al. **Technology of Machine Tools**, pp. 297-306, 285-286.

CONDITIONS FOR PERFORMANCE OF TASK:

Vertical milling machine
Work-holding device
Dial indicator
Spring loaded edgefinder
Vernier calipers
Offset boring head
Boring bars
Drills
Drill chuck
Center drill
Gage block
Machinist's handbook
Precision measuring rods
Micrometer heads
Rod holder
Blueprint
Workpiece

PERFORMANCE GUIDE

1. Mount work-holding device on milling machine table
2. Align work-holding device with dial indicator
3. Mount workpiece in work-holding device
4. Mount spring loaded edgefinder in spindle
5. Adjust table cross feed to center edgefinder on edge of workpiece
6. Mount dial indicator in spindle
7. Adjust indicator touching edge and at right angle to edge
8. Hold gage block against edge and rotate spindle 180°
9. Check readings at each position
10. Adjust table, if necessary
11. Move table required amount
    a. Mount V-trough with measuring rods, including micrometer head
    b. Adjust micrometer to indicate one half turn
    c. Lock table
    d. Set indicator to zero
    e. Increase rod length (with micrometer) amount required on blueprint
    f. Move table more than this distance
    g. Move table back until indicator registers zero
    h. Lock table
12. Follow steps 4-11 with longitudinal feed

13. Remove indicator and set mill speed for drilling
14. Center drill workpiece
15. Drill hole for boring
16. Mount offset boring head with boring bar in spindle
17. Set mill speed for boring
18. Adjust cutter for light cut on workpiece
19. Start mill and bore hole
20. Measure hole
21. Adjust boring bar and machine workpiece to designated dimension

LEARNING ACTIVITIES

1. Explain importance of proper mounting procedure of workholding device with dial indicator.
2. Demonstrate the setting up of workpiece with the edgefinder.
3. Explain the fundamentals of aligning workpiece length-wise and cross-wise with dial indicator for preferred accuracy.
4. Describe the consequences if workpiece is not center drilled before drilling hole for boring procedure.
5. Demonstrate the proper mounting of boring head in milling machine for obtaining clearance in boring of hole.
6. Check for desired speeds and feeds for boring head operation.
7. Have student start mill and bore hole to specifications.

RESOURCES

Repp and McCarthy. **Machine Tool Technology,** pp. 308-309.
Johnson. **General Industrial Machine Shop,** pp. 470-471.

EVALUATION

Written Questions

1. Name four or more tools used in setting up a workpiece on the milling machine for jig boring.
2. Why is the workpiece center drilled before using the finish drill size on the milling machine?

Answers

1. Dial indicator; edgefinder; offset boring head; center drill; drills; boring bar.
2. If workpiece is not center drilled, the drill bit will lead off center and possibly break, ruin the hole, or cause serious injury.

DUTY: OPERATING MILLING MACHINES

TASK: Machine Woodruff keyway

PERFORMANCE OBJECTIVE V-TECS 163

STANDARD: Keyway must be within a tolerance of ± 0.003" on decimal dimensions, ± 1/64" on fraction dimensions and/or meet blueprint specifications.

SOURCE OF STANDARD: Delmar. **Milling Machine Work**, pp. 214-216.
Oberg, et. al. **Machinery's Handbook**, 21st ed., pp. 974-977.

CONDITIONS FOR PERFORMANCE OF TASK:
Milling machine
Woodruff keyseat cutters
Woodruff keys
Machinist's handbook
Vise
Square
Micrometer caliper
Layout dye
Cutter arbor or collet
Dial indicator
Paper feeler
Soft hammer
Blueprint
Workpiece

PERFORMANCE GUIDE

1. Mount vise on mill table and align with dial indicator
2. Mount workpiece in vise
3. Select and mount keyseat cutter
4. Set speed of machine
5. Start machine
6. Move table until cutter touches paper feeler on workpiece
7. Adjust table and move table one-half diameter of workpiece plus one-half thickness of cutter
8. Lock saddle
9. Scribe line on workpiece indicating center of keyway
10. Move work lengthwise to locate center line of workpiece under center of cutter
11. Lock table
12. Start machine and raise table by bumping vertical feed crank until cut on workpiece is width of cutter (on vertical mill move crossfeed)
13. Set elevation dial on zero
14. Calculate depth of keyway
15. Feed to depth of cut by hand
16. Stop machine and lower table

17. Deburr workpiece
18. Tap Woodruff key in keyseat and measure with micrometer caliper (check machinist's handbook for required dimension)
    a. Accept workpiece, or
    b. Reject workpiece and/or take corrective action

LEARNING ACTIVITIES

1. Explain how to indicate vise on machine table using a dial indicator.
2. Demonstrate the correct way to cut a Woodruff keyway in existing workpiece.
3. Have student start machine and align cutter with workpiece and cut keyway to specifications using dial on machine.
4. Measure workpiece for accuracy with precision instrument before accepting.
5. With key installed check before removing from machine for correct depth.

RESOURCES

Repp and McCarthy. **Machine Tool Technology**, p. 345.
Johnson. **General Industrial Machine Shop**, p. 438.

EVALUATION

Written Questions

1. Give a brief explanation of centering cutter to machine Woodruff keyway on milling machine.
2. How is the depth of a Woodruff keyway determined on the milling machine?

Answers

1. To center the cutter, move the workpiece upward half the diameter plus half the cutter width plus thickness of paper or feeler.
2. Cutters are numbered. Refer to machinist handbook.

DUTY: OPERATING MILLING MACHINES

TASK: Mill an angular surface

PERFORMANCE OBJECTIVE V-TECS 167

STANDARD: Workpiece must meet blueprint specifications to an angular tolerance of ± 5 minutes.

SOURCE OF STANDARD: McCarthy and Smith. **Machine Tool Technology**, pp. 96-97.
Olivo. **Basic Machine Technology**, p. 15.

CONDITIONS FOR PERFORMANCE OF TASK:
Milling machine
Pre-machined workpiece
Angle plate
Clamps
Sine bar
Gage blocks
Vernier bevel protractor
Surface plate
Milling cutter
Machinist's handbook
Blueprint

PERFORMANCE GUIDE

1. Mount angle plate on surface plate
2. Calculate gage block measurement for sine bar
   a. Refer to machinist's handbook table/or
   b. Use formula and sine table
      Dimension = length of sine bar x sine of angle
3. Select and wring required gage blocks
4. Mount sine bar and gage blocks against angle plate
5. Mount workpiece on sine bar and clamp
6. Mount workpiece and angle plate on milling machine
7. Identify material of workpiece
8. Select and mount end cutter
9. Select and set speed, feed, and depth of cut
10. Make cut
11. Check surface and tolerance specifications, making machine adjustments
12. Machine to specifications

LEARNING ACTIVITIES

1. Identify correct attachment to be used in cutting angles on milling machine.
2. Explain the formula for setting sine bar to obtain correct angle, refer to machinist's handbook to find formula.
3. Select type of material to be machined.
4. Check for proper mounting of selected cutter.
5. Discuss the importance of correct feeds and speeds to maintain tolerances and care of cutter.
6. Have student machine to specifications.

RESOURCES

Johnson. **General Industrial Machine Shop**, p. 471.
Repp and McCarthy. **Machine Tool Technology**, pp. 313-315.

EVALUATION

Written Questions

1. What are the two most important attachments used in angular milling?
2. Why is the sine bar and gage blocks used in milling an angular surface?

Answers

1. Angle plate and surface plate
2. To select the correct angle, according to blueprint.

DUTY: OPERATING MILLING MACHINES

TASK: Mill an external radius with rotary table

PERFORMANCE OBJECTIVE V-TECS 168

STANDARD: Radius must be cut on workpiece to blueprint specifications within a tolerance of ± 0.005".

SOURCE OF STANDARD: Olivo. **Basic Machine Technology**, p. 15.

CONDITIONS FOR PERFORMANCE OF TASK:
Milling machine
Prepared workpiece
Wiggler
Rotary table
End mill cutter
Strap clamps
T-bolts
Step blocks
Dial indicator
Vernier calipers
Blueprint

PERFORMANCE GUIDE

1. Identify material of workpiece
2. Mount rotary table on milling machine
3. Center spindle over rotary table using dial indicator
4. Align and clamp workpiece to rotary table
5. Select and mount cutter
6. Select and set speed, feed, and depth of cut
7. Mill primary cut
   a. Make rough cut outside finished dimension
   b. Allow for adjustment in radius and depth
   c. Adjust table feed as required
8. Measure workpiece and re-adjust mill, if necessary
9. Check surface and tolerance of workpiece and mill to specifications

LEARNING ACTIVITIES

1. Check type of material: soft, hard, tough, abrasive, etc.
2. Explain the purpose of a rotary table and how to set it up for particular task.
3. Demonstrate the proper way to mount workpiece to rotary table.
4. Check for proper feeds and speeds.
5. Explain the purpose of a roughing cut and a finish cut.
6. Measure workpiece after roughing cut to determine the amount of finish cut.
7. Assign students to mill to job specifications.

RESOURCES

Johnson. **General Industrial Machine Shop**, p. 473.
Repp and McCarthy. **Machine Tool Technology**, p. 290.

EVALUATION

Written Questions

1. Name three operations that can be performed with rotary table.
2. TRUE or FALSE. Rotary tables can be equipped for accurate indexing just like dividing heads.

Answers

1. Milling curved slots; spacing holes at given angles apart; cutting angular surfaces.
2. True

DUTY: OPERATING MILLING MACHINES

TASK: Mill cylindrical work with rotary table

PERFORMANCE OBJECTIVE V-TECS 169

STANDARD: Workpiece must be milled to blueprint specifications and a tolerance of ± 0.005" on decimal dimensions and ± 1/64" on fraction dimensions.

SOURCE OF STANDARD: Olivo. **Basic Machine Technology**, p. 15.

CONDITIONS FOR PERFORMANCE OF TASK:

Milling machine
Cylindrical workpiece
Rotary table
Strap clamps
Wiggler
Step blocks
Dial indicator
Vernier calipers
End mill cutter
T-bolts
Blueprint

PERFORMANCE GUIDE

1. Clamp and align rotary table on mill table with dial indicator
2. Clamp and align workpiece
3. Select and mount cutter or tool
4. Identify material of workpiece
5. Select and set speed, feed, and depth of cut
6. Touch-off and mill to specifications
    a. Check rotary table setting
    b. Measure and make adjustments
    c. Allow for finish cut
7. Inspect surface and measure workpiece for accuracy
    a. Approve workpiece, or
    b. Reject workpiece and/or take corrective action

LEARNING ACTIVITIES

1. Describe the method of milling various shapes, slots and cams using a rotary table.
2. Demonstrate the proper method of attaching a rotary table to the table of a milling machine.
3. Demonstrate the use of the rotary table's longitudinal and cross feeds in conjunction with the rotary table's rotary movement.
4. Demonstrate the proper procedure for clamping and aligning workpiece o the rotary table.
5. Demonstrate the proper procedure used to select speed, feed and depth o cut according to the material to be machined.

PERFORMANCE OBJECTIVE V-TECS 169 continued

RESOURCES

Anderson and Tatro. **Shop Theory,** 6th edition, p. 339.

EVALUATION

Written Questions

1. Name the types of feeds and controls available on a rotary table.
2. Another name for the rotary table is ____________ ____________ ____________.

Answers

1. Manual feed
   Power feed
   Manual control
   Power control
2. Circular milling attachment

DUTY: OPERATING MILLING MACHINES

TASK: Mill workpiece using indexing operation

PERFORMANCE OBJECTIVE V-TECS 173

STANDARD: Workpiece must be machined to blueprint specifications and/or to a tolerance of ± 0.005" on decimal dimensions and ± 1/64" on fraction dimensions.

SOURCE OF STANDARD: Oberg, et. al. **Machinery's Handbook,** 21st ed., pp. 1499-1509.
Olivo. **Basic Machine Technology**, p. 15.

CONDITIONS FOR PERFORMANCE OF TASK:
Milling machine
Dividing head
Index plates
Footstock
Centers
Driving dog
Milling cutter
Dial indicator
Test bar
Micrometer caliper
Steel rule
Machinist's handbook
Blueprint
Workpiece

PERFORMANCE GUIDE

1. Identify material of workpiece
2. Mount and align dividing head with dial indicator and test bar
3. Select and mount cutter
4. Mount and align workpiece
5. Determine number of indexes workpiece must be rotated
6. Set up indexing unit of dividing head
7. Select and set up speed and feed
8. Touch off, make primary cut, and adjust for depth of cut
9. Measure for blueprint specifications, making necessary adjustments
10. Recut, if necessary
11. Rotate indexing unit for each subsequent cut specified
12. Inspect and measure finished part
    a. Accept workpiece, or
    b. Reject workpiece and/or take corrective action

LEARNING ACTIVITIES

1. Explain the uses of a dividing head and the proper aligning on the milling machine.
2. Demonstrate the correct procedure for using the dividing head, and the correct index plate for the job to be performed.
3. Select proper feed and speed.
4. Position cutter for roughing cut.

5. Check workpiece for correct measurement before making finish cut.
6. Have student machine part; inspect after completion for accuracy.

RESOURCES

Johnson. **General Industrial Machine Shop**, pp. 427-432.
Repp and McCarthy. **Machine Tool Technology**, pp. 324-326.

EVALUATION

Written Questions

1. What are the three most common uses of the dividing head on the milling machine?
2. What are the two most used index plates on the index or dividing head?

Answers

1. Gear cutting, grooves, hexagons and similar operations at specified angular distances apart.
2. Direct index plate or (1) 1:1 ratio -- (2) 40:1 ratio
   Ratio meaning -- the index head has 40 teeth on the worm wheel, therefore it takes 40 turns of the crank to make the spindle revolve one complete turn.

DUTY: OPERATING MILLING MACHINES

TASK: Mill gears to specifications

PERFORMANCE OBJECTIVE V-TECS170

STANDARD: Gear must be cut to blueprint specifications and a tolerance of zero to 0.002".

SOURCE OF STANDARD: Krar, et. al. **Technology of Machine Tools,** pp. 248-250.
Oberg, et. al. **Machinery's Handbook,** 21st ed., p. 762.

CONDITIONS FOR PERFORMANCE OF TASK:

Milling machine
Gear blank
Mandrel
Gear tooth cutter
Dividing head
Tailstock
Steady rest
Index plates
Dog
Centers
Dial indicator
Test bar
Square
Steel rule
Gear tooth vernier caliper
Machinist's handbook
T-bolts
Paper strip
Blueprint

PERFORMANCE GUIDE

1. Mount dividing head and tailstock on milling machine table
   a. Allow for length of mandrel
   b. Align with test bar and dial indicator
2. Calculate gear dimensions
3. Calculate indexing movements
   a. Number of turns = 40/number of divisions
   b. Select index plate for partial turns
4. Mount index plate on dividing head and set index crank and sector arms
5. Press gear blank on mandrel (check O.D.)
6. Mount mandrel and dog on centers of dividing head
   a. Lock foodstock center
   b. Check movement of dog in slot
   c. Lock dog
   d. Check cutter clearance with dog
   e. Mount center rest under gear blank
7. Select and mount gear cutter
   a. Mount near column for rigidity
   b. Cutter rotates toward dividing head

8. Center gear blank under cutter
    a. Use square against blank and measure to side of cutter
    b. Repeat on each side and adjust table until gear blank centered
9. Lock cross slide
10. Set speed and feed of mill
11. Start mill and raise table until cutter touches workpiece (use paper strip between cutter and blank)
12. Set graduated vertical feed dial on zero
13. Calculate depth of tooth
    a. Check size of cutter
    b. Check size in machinist's handbook
14. Move workpiece clear of cutter with longitudinal feed
15. Raise table about two thirds the depth of the tooth and lock knee clamp
16. Notch all gear teeth using indexing set up (use hand feed)
17. Check number of notches and correct, if necessary
18. Rough out first tooth and set automatic feed trip dog after cutter clears workpiece
19. Cut remaining teeth
20. Loosen knee clamp and raise to proper depth (lock knee clamp)
21. Adjust table feed for finish cut
22. Finish cut all teeth
23. Measure gear with gear tooth vernier caliper to assure tolerance
    a. Check dimensions in machinist's handbook, or
    b. Calculate dimensions using formulas in machinist's handbook

LEARNING ACTIVITIES

1. Explain how to select the proper attachments for gear cutting on the mill and how to attach to table.
2. Define the formula for cutting gear blanks, using the formula found in the textbook.
3. Demonstrate the mounting of a gear blank on mandrel and the setup of dividing head and footstock to secure workpiece for machining.
4. Explain the procedure for aligning cutter to assure the uniformity of teeth on gear blanks.
5. Show the student in a step by step demonstration how to start machine and approach workpiece.
6. Describe the procedure for cutting teeth with automatic feed, after checking for correct amount of teeth by touching workpiece with cutter and marking each tooth with hand feed.
7. Have student cut gear to specifications.
8. Check finished product to assure accuracy and tolerances uniformity and finish of teeth.

RESOURCES

Repp and McCarthy. **Machine Tool Technology**, pp. 352-368.
Johnson. **General Industrial Machine Shop**, Units 92-93.

EVALUATION

Written Questions

1. Name the four most important attachments used in the cutting of gears on a milling machine.
2. Explain the meaning of proper clearance when setting up the gear blank for cutting.

Answers

1. Dividing head, tailstock, center rest, dog, mandrel, correct cutter, and correct index plates for the dividing head.
2. Proper clearance means the cutter must have enough distance to clear the gear blanks before it strikes the dog that holds the mandrel in position on the dividing head and tailstock.

DUTY: OPERATING MILLING MACHINES

TASK: Mill work with carbide cutters

PERFORMANCE OBJECTIVE V-TECS 171

STANDARD: Workpiece must be machined to blueprint specifications and within a tolerance of ± 0.005" on decimal dimensions and ± 1/64" on fraction dimensions.

SOURCE OF STANDARD: Krar, et. al. **Technology of Machine Tools,** pp. 372-377.
Oberg, et. al. **Machinery's Handbook,** 21st ed., pp. 1768, 1779.

CONDITIONS FOR PERFORMANCE OF TASK:
Milling machine
Work-holding device
Carbide milling cutters
Micrometer caliper
Steel rule
Machinist's handbook
Dial indicator
Blueprint

PERFORMANCE GUIDE

1. Mount work-holding device on milling machine table and align with indicator
2. Mount workpiece in work-holding device
3. Select carbide milling cutter
4. Mount cutter on milling machine
5. Calculate speed and feed (refer to machinist's handbook)
6. Set speed and feed and start mill
7. Machine workpiece to blueprint specifications
8. Measure workpiece
    a. Accept workpiece, or
    b. Reject workpiece and/or take corrective action

LEARNING ACTIVITIES

1. Explain importance of having a rigid workholding device when cutting with carbide cutters.
2. Demonstrate aligning the workholding device with dial indicator.
3. Explain reasons why carbide cutters are used over conventional cutters.
4. Check for correct speed and feed for carbide cutters.
5. Have student machine to specifications.

RESOURCES

Johnson. **General Industrial Machine Shop,** pp. 437-438.
Repp and McCarthy. **Machine Tool Technology,** pp. 325-326.

EVALUATION

Written Questions

1. What are carbide cutters?
2. Give at least one advantage and one disadvantage of using carbide cutters on the milling machine.

Answers

1. Carbide cutters are made of solid carbide or cemented carbide inserts. A very hard but brittle metal that can endure higher speeds and feeds than conventional milling cutters.
2. Carbide cutters can be operated at a much higher speed; cut harder material than regular cutters; but cannot stand interrupted cuts and sudden impacts.

DUTY: OPERATING MILLING MACHINES

TASK: Machine work by straddle milling

PERFORMANCE OBJECTIVE V-TECS 164

STANDARD: Workpiece must be straddle milled to blueprint specifications and/or to an accuracy of ± 0.002".

SOURCE OF STANDARD: Delmar. **Milling Machine Work**, pp. 162-166.

CONDITIONS FOR PERFORMANCE OF TASK:
Milling machine
Vise
Side milling cutters
Milling machine arbor
Parallels
Steel rule
Square
Micrometer caliper
Scriber
Layout dye
Lead hammer
Spacing collars
Shims
Dial indicator
Blueprint
Workpiece

PERFORMANCE GUIDE

1. Identify material of workpiece
2. Mount arbor on mill
3. Select cutters (one right hand and one left hand half-side cutters)
4. Mount cutters on arbor
    a. Measure spacing collars
    b. Select spacing collars to obtain required dimension
    c. Use shims or adjustable spacing collar
5. Secure vise to machine table (using dial indicator)
6. Mount wokpiece
7. Select and set speed and feed
8. Align cutters to workpiece
9. Make preliminary cut
10. Measure and make adjustments, as necessary
11. Cut to specifications

LEARNING ACTIVITIES

1. Explain the absolute necessity of having the vise secured and indicated firmly on the machine table.
2. Identify the correct cutters to be used.
3. Specify correct mounting and spacing of cutters.
4. Demonstrate the correct procedure of mounting right and left hand cutters and the problems if they are not mounted correctly.

5. Check for exact feed and speed.
6. Have student run a trial cut, then make necessary adjustments and finish to size.

RESOURCES

Repp and McCarthy. **Machine Tool Technology**, p. 351.
Johnson. **General Industrial Machine Shop**, p. 457.

EVALUATION

Written Questions

1. What is meant by straddle milling?
2. What determines the width of workpiece when performing the straddle milling operation on the milling machine?

Answers

1. The operation of milling the two opposite sides at the same time.
2. The spacers used to hold the cutters at the correct distance apart.

DUTY: OPERATING MILLING MACHINES

TASK: Cut off work on mill

PERFORMANCE OBJECTIVE V-TECS 152

STANDARD: Tolerance of workpiece must be held to ± 1/64" on fraction dimensions and ± 0.005" on decimal dimensions.

SOURCE OF STANDARD: Olivo. **Basic Machine Technology,** p. 15.

CONDITIONS FOR PERFORMANCE OF TASK:
Horizontal milling machine
Work-holding device
Blocks
Assortment of cutters (metal-slitting saws, 1/4 staggered tooth cutter, etc.)
Arbor
Sleeves
Wrenches
T-bolts
Micrometer caliper
Steel rule
Machinist's handbook
Square
Dial indicator
Workpiece
Blueprint

PERFORMANCE GUIDE

1. Identify material of workpiece
2. Mount and align workpiece in work-holding device
    a. Use dial indicator
    b. Align within 0.002"
3. Select and mount cutter
    a. Note direction of rotation
    b. Mount close to column
4. Select and set speed, feed, and depth of cut
    a. Check blueprint
    b. Check machinist's handbook
5. Align workpiece to cutter
6. Cut off workpiece to specifications
    a. Use coolant as required
    b. Machine cut close to work-holding device

LEARNING ACTIVITIES

1. Explain the aligning procedure for mounting workpiece using dial indicator.
2. Describe the correct type of cutter to be used in cut-off operations.
3. Check speed and feed as this operation constitutes a much slower feed than ordinaary milling.
4. Explain the importance of cutting as close to workholding device as possible.

5. Emphasize the importance of cutting direction and the use of coolant to protect the cutter from overheating.
6. Have student cut workpiece to specifications.

RESOURCES

Repp and McCarthy. **Machine Tool Technology,** p. 324.
Johnson. **General Industrial Machine Shop,** p. 435.

EVALUATION

Written Questions

1. What type cutter is used in cut-off operations on milling machine?
2. Why is it important to cut as close to workholding device as possible?

Answers

1. Metal slitting saws with side cutting or staggered teeth.
2. To eliminate chatter and to give more stability for protection and longer wear of cutter.

DUTY: OPERATING MILLING MACHINES

TASK: Machine internal slots using slotter

PERFORMANCE OBJECTIVE V-TECS 162

STANDARD: Internal slot must be milled to a tolerance of $\frac{+0.010''}{-0.000''}$ and/or blueprint specifications.

SOURCE OF STANDARD: Heineman and Genevro. **Machine Tools Processes and Applications,** p. 223.

CONDITIONS FOR PERFORMANCE OF TASK:
Milling machine
Slotting attachment
Slotting cutter or tool
Workholding device
Vernier calipers
Blueprint
Workpiece

PERFORMANCE GUIDE

1. Mount work-holding device on mill table
2. Identify material of workpiece
3. Secure workpiece to table or in work-holding device
4. Mount slotting attachment on mill
5. Set slotting attachment at 90° or required angle
6. Position slotting attachment over table
7. Select and mount cutter
8. Select and adjust stroke length
9. Align cutter to workpiece
10. Set speed
11. Slot to specifications
    a. Measure workpiece after trial cut
    b. Make adjustments as required
12. Deburr workpiece and measure
    a. Accept workpiece, or
    b. Reject workpiece and/or take corrective action

LEARNING ACTIVITIES

1. Explain the procedure for mounting workholding device.
2. Demonstrate correct mounting of slotting attachment to head of milling machine.
3. Discuss the importance of setting stroke on slotter, as incorrect setting could damage machine, ruin workpiece, or cause an injury.
4. Check for correct speed.
5. Have student begin slotting operation with trial cut. Measure and finish to specifications.

RESOURCES

Repp and McCarthy. **Machine Tool Technology,** p. 317.
Johnson. **General Industrial Machine Shop,** p. 433.

EVALUATION

Written Questions

1. Why is the setting of the stroke of the slotter the most important step in using the slotting attachment on the milling machine?
2. Does the slotting attachment operate in a circular motion or a reciprocating motion?

Answers

1. If stroke is incorrectly set, the housing of slotter may strike workpiece causing damage to tool, workpiece, and housing of slotter.
2. Reciprocating motion.

DUTY: **OPERATING MILLING MACHINE**

TASK: Duplicate on the profile milling machine

PERFORMANCE OBJECTIVE V-TECS 154

STANDARD: Workpiece msut be within blueprint specifications and/or to a tolerance of ± 0.002".

SOURCE OF STANDARD: Kentucky Writing Team, Incumbent Workers and Instructors.

CONDITIONS FOR PERFORMANCE OF TASK:
Milling machine
Work-holding device
Pattern
Pattern holding device
Milling cutter
Matching stylus
Indicating and centering device
Micrometer caliper
Gages
Machinist's handbook
Blueprint
Workpiece

PERFORMANCE GUIDE

1. Mount and align work-holding device
2. Mount and align pattern holding device
3. Mount workpiece and pattern
4. Select and mount milling cutter and stylus
    a. Check workpiece contour
    b. Check tracer controls
5. Adjust stylus position over pattern and workpiece
6. Select and set speed and feed
    a. Check workpiece material
    b. Check tracer control
7. Duplicate the profile
    a. Check workpiece after first trial cut
    b. Observe cutting for any required feed change
8. Measure workpiece to determine accuracy
9. Make adjustments and machine to specifications

LEARNING ACTIVITIES

1. Explain the aligning of workholding device on milling machine table.
2. Explain the importance of positioning the pattern for accurate tracing of profile to be machined.
3. Check for correct speeds and feeds.
4. Check for clearance of stylus of tracer as any obstruction can adversely change profile of cut.
5. Assign student to make trial cut and adjust machine if necessary. Then finish to specifications.

RESOURCES

Johnson. **General Industrial Machine Shop,** p. 424.
Repp and McCarthy. **Machine Tool Technology,** pp. 300-310.

EVALUATION

Written Questions

1. What is the tracing stylus' function in profile milling on the milling machine?
2. What is profile milling?

Answers

1. It is connected to the cutting tool by pantograph arm linkage and follows the exact contours that are being duplicated. This causes the tool to exactly duplicate the path of movement.
2. The making of parts using a tracing attachment set up on a pattern of contours and dimensions as part to be made.

SHAPERS

DUTY: OPERATING SHAPERS

TASK: Clean and lubricate the shaper

PERFORMANCE OBJECTIVE V-TECS 176

STANDARD: Shaper must be cleaned and lubricated according to operator's manual specifications.

SOURCE OF STANDARD: Kibbe, et. al. **Machine Tool Practices,** p. 706.

CONDITIONS FOR PERFORMANCE OF TASK:
Furnished with shaper
Operator's manual
Cleaning solvent
Rags
Brush
Lubricating oil

PERFORMANCE GUIDE

1. Turn off power
2. Clean shaper with brush
3. Clean shaper with rags and cleaning solvent
4. Check operator's manual and visual check for oil holes and cups
5. Oil cup and holes
6. Lubricate parts with pressure lubrication, if available
7. Oil slides and machined surfaces (wipe off excess)
8. Check sight glass lubrication oil levels and add when required

LEARNING ACTIVITIES

1. Identify the parts to the shaper that would need lubricating.
2. Demonstrate cleaning with rags, brush, and solvent.
3. Discuss how to check for oil holes and cups
4. Discuss problems caused by lack of proper lubrication.
5. Discuss problems caused by too much oil.

RESOURCES

Johnson. **General Industrial Machine Shop,** p. 389.

EVALUATION

Written Questions

1. Should all oil cups on the shaper be filled?
2. When and how should the shaper be cleaned?

Answers

1. All oil cups should be kept full at all time.
2. The shaper should be cleaned after each use with a hair brush and wiped down with a clean oiled rag.

DUTY: OPERATING SHAPERS

TASK: Select and set speeds and feeds for machining

PERFORMANCE OBJECTIVE V-TECS 181

STANDARD: Speeds and feeds of shaper must be according to blueprint specifications.

SOURCE OF STANDARD: Kentucky Writing Team, Incumbent Workers and Instructors.

Oberg, et. al. **Machinery's Handbook,** 21st ed., p. 175 (Table 1).

CONDITIONS FOR PERFORMANCE OF TASK:
Furnished with shaper
Machinist's handbook
Shaper operations manual
Shaper hand tools
References
Workpiece
Blueprint

PERFORMANCE GUIDE

Select and Set for Cutting Speed

1. Identify and classify material of workpiece
2. Identify cutter
3. Determine cutting speed using table specifications
4. Determine setting of cutting speed based on length of cut and shaper strokes per minute
5. Set up shaper for cutting speed following operations manual

Select and Set Feed

1. Identify and classify material of workpiece
2. Identify cutter material
3. Determine cutting speed
4. Determine depth of cut needed
5. Determine feed according to required finish
6. Set feed according to operations manual

LEARNING ACTIVITIES

1. Lecture on speed and feed settings on shaper.
2. Demonstrate proper speeds for different steels.
3. Demonstrate proper feeds for different steels.
4. Explain how to use the table specifications.
5. Explain proper set up in speed and feed.

RESOURCES

Felkel. **Machine Shop Technology,** p. 291.
Johnson. **General Industrial Machine Shop,** Section 8 (Unit 64).

EVALUATION

Written Questions

1. Identify the cutting speed of the shaper.
2. What is the amount of feed based on for the shaper?

Answers

1. Cutting speed for the shaper is the distance per minute the cutting tool moves over the workpiece.
2. The feed is based on the depth of cut, the cutting speed, and the finish desired on a cut in the shaper.

DUTY: **OPERATING SHAPERS**

TASK: Machine flat surface on shaper

PERFORMANCE OBJECTIVE V-TECS 179

STANDARD: Workpiece must meet blueprint specifications and be within a tolerance of ± 0.005" on decimal dimensions and ± 1/64" on fraction dimensions.

SOURCE OF STANDARD: McCarthy and Smith. **Machine Tool Technology,** pp. 302-304.

CONDITIONS FOR PERFORMANCE OF TASK:
Furnished with shaper
Shaper tools
Tool holders
Parallels
Shaper vise
Square
Micrometer caliper
Layout dye
Scriber
Soft hammer
Machinist's handbook
Dial indicator
Blueprint

PERFORMANCE GUIDE

1. Layout workpiece (clean and deburr)
2. Align vise with dial indicator
3. Mount workpiece in vise on parallels
4. Select and mount tool and toolholder
   a. Avoid excessive overhang
   b. Incline clapper box slightly away from direction of cut
5. Determine and set length of stroke (L + 3/4")
6. Position ram until tool extends 1/4" beyond workpiece
7. Determine cutting speed
8. Set speed $N = \frac{CS \times 7}{L}$

   N = number of strokes
   CS = cutting speed
   L = length of stroke
9. Position workpiece under cutting tool
10. Set shaper feed
    a. Direction of cut
    b. Feed/stroke
11. Start shaper and lower cutting tool to work
12. Determine depth of cut and machine workpiece
13. Measure workpiece and continue machining workpiece to designated dimension

LEARNING ACTIVITIES

1. Explain how to adjust vise parallel to the stroke of the ram.
2. Demonstrate how ram must be set to cut over the work from end to end.
3. Explain the position of the clapper box and setting.
4. Demonstrate the shape of the proper tool.
5. Demonstrate square vise with indicator.

RESOURCES

Johnson. **General Industrial Machine Shop**, p. 395.
Felkel. **Machine Shop Technology**, p. 291.

EVALUATION

Written Questions

1. Define the length of stroke for machining a flat surface on shaper.
2. Explain how to mount workpiece in vise when machining flat surface on shaper.

Answers

1. The length of stroke in machining flat surface would be the length of workpiece plus 1/2 inch.
2. When mounting workpiece in the vise for machining flat surface, first use dial indicator to square the vise (on fixed). Then, place paper strips under workpiece. Tap gently with mallet until paper strips are snug.

DUTY: OPERATING SHAPERS

TASK: Cut a vertical surface on shaper

PERFORMANCE OBJECTIVE V-TECS 177

STANDARD: Workpiece msut meet blueprint specifications and be within ± 1/64" on fraction dimensions and ± 0.005 on decimal dimensions.

SOURCE OF STANDARD: McCarthy and Smith. **Machine Tool Technology,** pp. 306-308.
Olivo. **Basic Machine Technology,** p. 15.

CONDITIONS FOR PERFORMANCE OF TASK:
Furnished with workpiece
Blueprint
Shaper
Shaper tools
Tool holders
Parallels
Shaper vise
Square
Micrometer
Caliper
Layout dye
Scriber
Soft hammer
Machinist's handbook
Dial indicator

PERFORMANCE GUIDE

1. Layout point of cut on workpiece
2. Align vise with dial indicator
3. Mount workpiece in vise on parallels
    a. Allow overhang for tool clearance
    b. Seat with soft hammer
4. Select tool and tool holder
5. Swivel clapper box 15° to 20° away from workpiece
6. Mount tool and toolholder on clapper box
7. Determine and set length of stroke (L + 3/4")
8. Position ram until tool extends 1/4" past workpiece and clamp
9. Determine cutting speed
10. Set speed: $N = \frac{CS \times 7}{L}$

    N = number of strokes
    CS = cutting speed
    L = length of stroke in inches
11. Position workpiece under cutting tool and lock table
12. Hand feed ram through one complete stroke
    a. Check clearance of toolhead
    b. Check position of ram
    c. Adjust, if necessary

13. Start shaper and hand feed tool for start of cut
14. Check position and make adjustments
15. Complete cut and measure
16. Continue cuts and measuring until workpiece is cut to specified tolerance

LEARNING ACTIVITIES

1. Demonstrate alignment of vise with indicator.
2. Determine and set length of stroke.
3. Select proper tool and tool holder.
4. Determine feed and speed.
5. Discuss layout of workpiece.

RESOURCES

Johnson. **General Industrial Machine,** p. 403.
Felkel. **Machine Shop Technology,** p. 309.

EVALUATION

Written Questions

1. Explain the down feed of the shaper cutter.
2. Explain cutting tool overhang of the shaper.

Answers

1. Down feed of the shaper cutter is the direction the cutter is fed to make a cut.
2. Cutting tool overhang on the shaper is the clearance of clapper box from the stock at the beginning cut.

DUTY: **OPERATING SHAPERS**

TASK: Cut angular surface on shaper

PERFORMANCE OBJECTIVE V-TECS 178

STANDARD: Workpiece must meet blueprint specifications and be within a tolerance of ± 1/64" on fraction dimensions and ± 1° on angular dimensions.

SOURCE OF STANDARD: McCarthy and Smith. **Machine Tool Technology,** pp. 306-308.
Olivo. **Basic Machine Technology,** p. 15.

CONDITIONS FOR PERFORMANCE OF TASK:
Furnished with shaper
Shaper tools and toolholders
Shaper vise
Vernier bevel protractor
Layout dye
Scriber
Machinist's handbook
Dial indicator
Blueprint

PERFORMANCE GUIDE

1. Layout workpiece for angle cut
2. Align vise with dial indicator
3. Mount workpiece in vise
   a. Layout line parallel with top of vise and use automatic table feed/or
   b. Swivel vise at required angle and use automatic table feed/or
   c. Swivel tool slide to required angle
4. Select tool and tool holder
5. Swivel clapper box 15° to 20° away from workpiece
6. Mount tool and toolholder on clapper box
7. Determine and set length of stroke (L + 3/4)
8. Position ram until tool extends 1/4" past workpiece and clamp
9. Determine cutting speed
10. Set speed: $N = \frac{CS \times 7}{L}$

    N = number of strokes
    CS = cutting speed
    L = length of stroke in inches
11. Position workpiece under cutting tool and lock table
12. Hand feed ram through one complete stroke
    a. Check clearance of toolhead
    b. Check position of ram
    c. Adjust
13. Start shaper and hand feed tool for start of cut
14. Check position and make adjustments
15. Complete cut and measure
16. Continue cuts and measuring until workpiece is cut to specified tolerance

LEARNING ACTIVITIES

1. Demonstrate layout of workpiece for angle cut.
2. Demonstrate set up of workpiece.
3. Select proper tool and toolholder.
4. Compute feed and speed.
5. Discuss different methods of angle cutting.

RESOURCES

Johnson. **General Industrial Machine,** p. 404.
Felkel. **Machine Shop Technology,** p. 298.

EVALUATION

Written Question

Name three ways to make angle cuts on the shaper.

Answer

Angular cuts may be made by:

1. Setting cutting edge of the tool at an angle corresponding to the angle to be produced on the workpiece.
2. By setting workpiece at an angle.
3. By swiveling the toolhead to guide the tool in an angular direction.

DUTY: OPERATING SHAPERS

TASK: Machine keyway on shaper

PERFORMANCE OBJECTIVE V-TECS 180

STANDARD: Workpiece must meet blueprint specificaitons and be within a tolerance of ± 1/64" on fraction dimensions and fit a key.

SOURCE OF STANDARD: McCarthy and Smith. **Machine Tool Technology,** pp. 309-310.

CONDITIONS FOR PERFORMANCE OF TASK:
Furnished wth shaper
Shaper vise
Wheel workpiece
Shaper boring bar holder
Boring bar
Cutting tool
Layout dye
Square
Scriber
Key steel rule
Micrometer caliper
Dial indicator
Blueprint

PERFORMANCE GUIDE

1. Locate and mark position of keyway on workpiece
2. Align vise with dial indicator
3. Mount workpiece in vise
    a. Align vertically
    b. Align with keyway on bottom center
4. Secure toolholder and cutting tool and amount
    a. Grind tool to width of keyway, with clearance
    b. Mount boring bar holder vertically and with as short a bar as possible
5. Move workpiece clear of ram
6. Set length of stroke and position of ram
7. Determine and set cutting speed
8. Position table
    a. Center cutting tool in keyway layout
    b. Clamp table
9. Start shaper and hand feed depth of cut to required dimension
    a. Use only 0.002" feed/cut
    b. Feed on return stroke
    c. Check fit of key in keyway

LEARNING ACTIVITIES

1. Demonstrate aligning vise with dial indicator.
2. Explain setting length of cutter stroke.
3. Lecture on setting cutting tool in keyway layout.
4. Demonstrate how to check for proper fit.
5. Explain how to determine cutting speed.

RESOURCES

Felkel. **Machine Shop Technology**, p. 291.
Johnson. **General Industrial Machine Shop**, p. 392.

EVALUATION

Written Questions

1. The amount of feed per cut in machining a keyway on shaper is based on __________________________.
2. How much should be taken off each cut to machine keyway on shaper?

Answers

1. The depth of cut and the cutting speed determines the amount of feed to be used when cutting a keyway in the shaper.
2. The correct depth per cut when cutting a keyway in the shaper is six to eight thousandths per cut.

WELDING

DUTY: **WELDING**

TASK: Arc weld workpiece in flat position

PERFORMANCE OBJECTIVE V-TECS 182

STANDARD: Workpieces must be welded to blueprint specifications.

SOURCE OF STANDARD: Oberg, et. al. **Machinery's Handbook**, pp. 2210-2212.
Althouse, et. al. **Modern Welding**, pp. 5-8, 5-9.

CONDITIONS FOR PERFORMANCE OF TASK:
Arc welder
Electrode holder
Electrodes
Grinder
Wire brush
Chipping hammer
Gloves
Helmet
Clamps
Work-holding device
Welding table
Machinist's handbook

PERFORMANCE GUIDE

1. Clean workpieces and grind beveled edges (wear goggles)
2. Clamp workpieces on welding table
3. Select electrode (see machinist's handbook) and place in holder
    a. Determine work material and thickness
    b. Determine size of electrode and electrode material
4. Determine and set welder controls as required
5. Start welder (caution: wear gloves and helmet)
6. Tack weld at each end of joint (some set-ups require several tack welds)
7. Weld workpieces to specifications
    a. Check weld for rate of feed
    b. Check weld for arc length
    c. Adjust and make necessary passes
8. Clean weld and chipping hammer and wire brush
9. Observe weld and check against blueprint specifications
    a. Accept welded workpiece, or
    b. Reject welded workpiece and/or take corrective action

LEARNING ACTIVITIES

1. Explain DC arc welding and AC arc welding.
2. Explain voltage and current requirement according to size of electrode and length of gap and heat requirements.
3. Demonstrate setting welder controls in relationship to work thickness, material, and size of electrodes.
4. Demonstrate correct rate of feed, length of arc and how to determine correct number of passes.

PERFORMANCE OBJECTIVE V-TECS 182 continued

RESOURCES

Oberg, et. al. **Machinery's Handbook**, pp. 2210-2212.
Althouse, et. al. **Modern Welding**, pp. 5-8, 5-9.

EVALUATION

Written Questions

1. Identify the digits in the electrode classification number E-6013.
2. Identify the letters in these abbreviations:
   - a. DCSP
   - b. DCRP
3. Which polarity produces the deepest penetration?

Answers

1. E = electrode
   6 = 60,000 #
   0 = tensil strength
   1 = position (to be used)
   3 = type of flux coating
2.

D = direct	D = direct
C = current	C = current
S = straight	R = reversed
P = polarity	P = polarity

3. DCSP

DUTY: **WELDING**

TASK: Braze workpiece or fixture

PERFORMANCE OBJECTIVE V-TECS 183

STANDARD: Workpiece must be brazed to blueprint specifications.

SOURCE OF STANDARD: Oberg, et. al. **Machinery's Handbook**, p. 2198.

CONDITIONS FOR PERFORMANCE OF TASK:
Oxy-acetylene welding outfit
Torches
Tips
Wire brush
Grinder
Filler rods
Fluxes
Clamping device
Welding table
Cleaning solvent
Gloves
Welding goggles
Blueprint

PERFORMANCE GUIDE

1. Clean workpiece
    a. Wire brush area of joint
    b. Grind bevel when necessary
    c. Remove all oil and grease with cleaning solvent
2. Clamp workpieces on welding table
3. Select torch and torch tip
4. Mount torch and tip on welder
5. Set and adjust tank valve pressures
6. Select filler rod and flux
7. Apply flux to filler rod or workpiece (wear gloves and welding goggles)
8. Light torch and adjust flame
9. Braze weld workpiece
    a. Apply flux as needed
    b. Tin workpiece surfaces
    c. Add filler rod
    d. Avoid overheating workpiece or filler rod
10. Clean brazed joint
11. Inspect brazed joint and make any necessary corrections according to specifications

LEARNING ACTIVITIES

1. Demonstrate cleaning and beveling; emphasize surface must be free of rust and grease.
2. Demonstrate clamping workpiece to provide best fit and machanical strength.

3. Explain how to properly select torch and tip to suit size and type material of workpiece.
4. Explain properties of flux and effects of using flux in brazing.
5. Demonstrate lighting and adjusting torch to produce carburizing flame.
6. Demonstrate tinning, adding filler and overheating work piece to avoid burnout of brass.

RESOURCES

Althouse, et. al. **Modern Welding**, pp. 16-21, 25.

EVALUATION

Written Questions

1. List the main constituents of brass.
2. What might cause a coppery appearance in some brazed joints?
3. Why is proper size tip important?

Answers

1. Copper and zinc
2. Some of the zinc may have been burned out due to overheating.
3. Small tips may not provide enough heat for large parts; large tips provide too much heat for thin parts.

DUTY: **WELDING**

TASK: Cut work with cutting torch

PERFORMANCE OBJECTIVE V-TECS 184

STANDARD: Workpiece must meet blueprint specifications and meet a tolerance of ± 1/16".

SOURCE OF STANDARD: Althouse, et. al. **Modern Welding**, pp. 3-6.

CONDITIONS FOR PERFORMANCE OF TASK:

Blueprint
Specifications
Oxy-acetylene welding outfit
Cutting torch
Tips
Tip cleaner
Wire brush
Grinder
Welding table
Stag container
Clamps
Steel rule
Scriber
Tip cleaner
Gloves
Welding goggles
Steel rule
References

PERFORMANCE GUIDE

1. Clean workpiece (wire brush/or grinder)
2. Layout cut on workpiece
3. Place workpiece on welding bench (locate cut clear of welding bench)
4. Place slag container under workpiece
5. Select and assemble cutting equipment
    a. Check reference for orifice size
    b. Check work thickness
    c. Clean tip if necessary
6. Adjust tank pressures
    a. See references
    b. Light torch and adjust flame (wear gloves and welding goggles)
    c. Make short trial cut on scrap
7. Torch cut workpiece to specifications
    a. Cut on waste side of layout line
    b. Check slag stream and adjust feed if necessary
    c. Clean off slag left on workpiece

PERFORMANCE OBJECTIVE V-TECS 184 continued

LEARNING ACTIVITIES

1. Demonstrate marking and laying out workpiece to avoid excess cutting and show waste side of layout line.
2. Explain necessity of placing workpiece clear of work-table with air space between it and slag container.
3. Explain factors to determine size of tip required in relation to thickness of workpiece.
4. Demonstrate adjusting tank pressure to ensure clean cut with thinnest kerf possible.
5. Let students practice making cuts on scrap.

RESOURCES

Althouse, et. al. **Modern Welding**, pp. 3-6.

EVALUATION

Written Questions

1. Name two advantages of cutting metal with oxyacetylene torch.
2. Why are welding hoses colored?
3. Why are regulators used?

Answers

1. a. Very fast, portable cutting method
   b. Intricate shapes may be cut
2. A safety precaution to prevent accidentally connecting hoses to wrong tank and to identify oxygen from acetylene.
3. To control gasses at constant working pressure.

DUTY: WELDING

TASK: Weld workpiece with oxy-acetylene torch

PERFORMANCE OBJECTIVE V-TECS 189

STANDARD: Workpiece must be welded to meet blueprint specifications and be within a tolerance of ± 1/32".

SOURCE OF STANDARD: Althouse, et. al. **Modern Welding**, pp. 1-9.

CONDITIONS FOR PERFORMANCE OF TASK:
- Workpiece
- Blueprint
- Oxy-acetylene welding outfit
- Torches
- Tips
- Tip cleaner
- Welding table
- Clamps
- Filler rod
- Goggles
- Gloves
- Steel rule
- Grinder
- Wire brush
- Abrasive paper
- Work-holding device

PERFORMANCE GUIDE

1. Clean workpiece (bevel if necessary)
2. Clamp workpiece in work-holding device on table
3. Select and assemble torch and clean tip to welding outfit
4. Select filler rod (size and material)
5. Set up welding outfit for welding
   a. Adjust and set tank pressures
   b. Light and adjust flame (CAUTION: Wear gloves and goggles)
6. Weld workpiece
   a. Tack welds may be required
   b. Apply filler rod as needed
   c. Wire brush completed weld joint
7. Verify weld within or without specifications and a tolerance of + 1/32"
   a. Accept workpiece, or
   b. Reject workpiece and/or take corrective action

LEARNING ACTIVITIES

1. Demonstrate cleaning with wire wheel mounted on motor.
2. Demonstrate beveling and explain purpose for beveling.
3. Explain the selection of tip to match thickness of metal and demonstrate assembly of torch.
4. Explain and/or demonstrate adjustment of regulator pressures for oxygen and acetylene (caution students about turning knobs correct way to prevent damage to valve diaphram).

5. Demonstrate lighting and adjusting flame.
6. Demonstrate making the weld; applying filler as needed.
7. Let students practice welding under supervision.

RESOURCES

Althouse, et. al. **Modern Welding**, pp. 1-9.

EVALUTION

Written Questions

1. What is meant by undercutting a welded joint?
2. Why should cylinder valves be opened slowly?
3. Where is the hottest part of the flame?

Answers

1. The parent metal is melted thinner near the weld.
2. To prevent damage to diaphrams.
3. In the blue cone.

DUTY: WELDING

TASK: Silver solder carbide tools

PERFORMANCE OBJECTIVE V-TECS 188

STANDARD: Workpiece must meet blueprint specifications.

SOURCE OF STANDARD: Althouse, et. al. **Modern Welding**, p. 15-1.

CONDITIONS FOR PERFORMANCE OF TASK:
- Blueprint
- Workpiece
- Oxy-acetylene welding outfit
- Torches
- Tips
- Silver solders
- Flux
- Carbide tip
- Carbide toolholder
- Goggles
- Gloves
- Work-holding device
- Welding table
- References
- Abrasive paper
- Clamps
- Tip cleaner

PERFORMANCE GUIDE

1. Clean and mount workpiece on table in work-holding device
2. Select and mount torch and tip
3. Select flux and filler material (solder)
4. Clamp carbide tip in carbide toolholder
5. Adjust welding outfit for soldering
    a. Set tank pressures
    b. Clean torch tip
    c. Light torch and adjust flame
6. Solder carbide tip to carbide tool holder
    a. Use flux
    b. Add filler rod
    c. Avoid excessive filler rod material
    d. Do not overheat tool holder
    e. Clean workpiece
7. Examine workpiece
    a. Accept workpiece as within blueprint specifications, or
    b. Reject workpiece and/or rework workpiece to specifications

LEARNING ACTIVITIES

1. Explain soldering principles of silver solder alloys, melting temperature and types of flux should be included.
2. Demonstrate cleaning and proper clamping methods to ensure proper fit.
3. Caution students about excessive filler rod use and overheating tool holder.
4. Demonstrate tip selection and adjusting flame for heat control.
5. Let students demonstrate silver soldering carbide tools.

RESOURCES

Althouse, et. al. **Modern Welding**, p. 15-1.

EVALUATION

Written Questions

1. What is the purpose of the flux?
2. What metals are contained in silver solder?

Answers

1. Flux produces and maintains a chemically clean surface and excludes oxygen from the molten metal.
2. 95% cadmium and 5% silver.

DUTY: **WELDING**

TASK: Pad shafts with arc welders for machining

PERFORMANCE OBJECTIVE V-TECS 187

STANDARD: Workpiece must be built up oversize to allow machining to blueprint specifications to a tolerance of ± 1/8".

SOURCE OF STANDARD: Althouse, et. al. **Modern Welding**, p. 5-1.

CONDITIONS FOR PERFORMANCE OF TASK:
Workpiece
Blueprint
Arc welder
Work-holding device
Electrodes
Calipers
Steel rule
Helmet
Gloves
Chipping hammer
Wire brush

PERFORMANCE GUIDE

1. Clean and clamp workpiece in work-holding device
2. Calculate amount of build up required
   a. Blueprint dimension
   b. Workpiece size
3. Select electrode
   a. Work piece material and size
   b. Size of rod and rod material
4. Set machine controls for welding
5. Run beads on workpiece
6. Measure workpiece and add beads as necessary
7. Clean, examine and measure finished weld
   a. Accept workpiece, or
   b. Rework weld to specifications

LEARNING ACTIVITIES

1. Demonstrate cleaning with wire brush and show best way to clamp workpiece in workholding device.
2. Explain methods for calculating amount of build-up required; refer to blueprints and/or determine size from bearing or part to which it must conform.
3. Explain that selection of electrode must match work piece size and type of material.
4. Demonstrate setting controls for welding in the proper heat range.
5. Demonstrate running beads on workpiece to make solid weld with no slag inclusion or porosity.
6. Measure periodically to determine whether sufficient build-up has been attained.
7. Let student practice or demonstrate welding to buildup shaft.
8. Examine welds and reject or accept workpiece.

RESOURCES

Althouse, et. al. **Modern Welding**, p. 5-1.

EVALUATION

Written Questions

1. Why should the thickness of weld be measured periodically?
2. Why should slag inclusions be avoided?

Answers

1. To ensure sufficient metal for turning to original size.
2. Weld will be weak and voids will appear after shaft is turned.

DUTY: **WELDING**

TASK: Heliarc weld workpiece in flat position

PERFORMANCE OBJECTIVE V-TECS 185

STANDARD: Workpiece must meet blueprint specifications and be within a tolerance of ± 1/32".

SOURCE OF STANDARD: Althouse, et. al. **Modern Welding**, pp. 12-15.

CONDITIONS FOR PERFORMANCE OF TASK:
Arc welder
Gas tungsten-arc-welding torch
Tungsten electrodes
Nozzles
Helium supply
Filler rods
Welding table
Clamps
References
Wire brush
Gloves
Helmet
Steel rule
Workpiece
Blueprint

PERFORMANCE GUIDE

1. Review blueprint
   a. Workpiece material
   b. Workpiece size
2. Clean and mount workpiece on welding table
3. Select welding accessories (refer to references)
   a. Electrode
   b. Nozzle
   c. Filler rod
4. Set up torch for welding
   a. Assemble torch
   b. Adjust tank pressure
   c. Check coolant supply
5. Heliarc workpiece to specifications (wear gloves and helmet)
   a. Tack weld workpiece
   b. Adjust toch angle, arc length, and torch speed
   c. Add filler rod as required
   d. Wire brush completed weld
   e. Assure workpiece within specifications, or
   f. Reject workpiece and/or take corrective action

LEARNING ACTIVITIES

1. Explain that the workpiece material and workpiece size will be important factors in determining type current used and adjustments to be made on welder and tanks.
2. Demonstrate selection of welding accessories and preparation of electrode.
3. Explain how to use reference tables to determine best set up for welding task.
4. Demonstrate torch assembly helium tank and coolant adjustment.
5. Demonstrate making weld noting torch angle, arc length, and torch speed.
6. Let student demonstrate making welds on small specimens.

RESOURCES

Althouse, et. al. **Modern Welding**, pp. 12-15.

EVALUATION

Written Question

Why is helium used in heliarc welds?

Answer

Helium shields the weld from oxygen and improves porosity of molten metal.

DUTY: **WELDING**

TASK: Machine workpiece with electro discharge machine (EDM)

PERFORMANCE OBJECTIVE V-TECS 186

STANDARD: Workpiece must meet blueprint specifications and be within a tolerance of ± 0.002".

SOURCE OF STANDARD: Krar, et. al. **Technology of Machine Tools,** pp. 443-449.
Walker. **Machining Fundamentals,** pp. 427-429.

CONDITIONS FOR PERFORMANCE OF TASK:
Workpiece
Blueprint
Electrodischarge machine
Electrodes
Electrode holder
Dielectric fluid
Work-holding device
Vernier calipers
References or operator's manual

PERFORMANCE GUIDE

1. Clamp workpiece in work-holding device
2. Mount electrode in holder on machine
3. Adjust machine for cutting (see references)
    a. Amperage setting
    b. Voltage setting
    c. Servo setting (amount of feed and depth)
    d. Dielectric flow (type of flow and amount)
4. Machine workpiece on electrodischarge machine
    a. Use roughing electrode first
    b. Check wear on electrode
    c. Measure hole and adjust machine if necessary
    d. Adjust machine for finish cut and machine to specifications

LEARNING ACTIVITIES

1. Explain the principle of electro discharge machining.
2. Describe machining shapes and sizes of EDM electrode and various materials used as electrodes.
3. Demonstrate the following adjustments:
    a. Amperage setting
    b. Voltage setting
    c. Servo setting
    d. Dielectric flow.
4. Demonstrate roughing out workpiece on EDM.
5. Demonstrate ways to check for wear on electrode and make finish cut.
6. Allow students to practice machining with EDM.

RESOURCES

Krar, et. al. **Technology of Machine Tools,** pp. 449-455.
Walker. **Machining Fundamentals,** pp. 427-429.

EVALUATION

Written Questions

1. Name three materials used as electrodes.
2. Why should electrode never touch workpiece?
3. What shapes may be machined using EDM?

Answers

1. Copper, carbon, brass
2. It may weld to it and machining will stop.
3. It is best used for odd shapes and difficult metals.

HEAT TREATMENT

DUTY: PERFORMING HEAT TREATMENT TASKS

TASK: Harden workpiece

PERFORMANCE OBJECTIVE V-TECS 191

STANDARD: The workpiece must meet blueprint specifications to a tolerance of ± 3 on Rockwell C reading.

SOURCE OF STANDARD: McCarthy and Smith. **Machine Tool Technology,** p. 618.
Oberg, et. al. **Machinery's Handbook,** p. 2142, 2149.

CONDITIONS FOR PERFORMANCE OF TASK:
Heat treat oven with accessories
Quench bath
Tool steel workpiece
Rockwell hardness tester and accessories
File
Tongs
Face shield
Gloves

PERFORMANCE GUIDE

1. Determine workpiece material and thickness
2. Set oven at hardening temperature (see handbook)
3. Place workpiece in oven and start oven (use tongs)
4. Soak workpiece at required temperature until heated uniformly
5. Prepare quench bath
6. Remove workpiece with tongs and quench (wear face shield)
   a. Agitate workpiece up and down in quench bath
   b. Test with file corner for hardness
7. Temper workpiece
   a. Set oven at tempering temperature (see handbook)
   b. Place workpiece in oven with tongs and soak at tempering temperature for one hour per inch thickness
   c. Remove workpiece from furnace with tongs and cool in air
8. Test hardness of workpiece on hardness tester
   a. Accept workpiece as within blueprint specifications and tolerances, or
   b. Reject workpiece and/or take corrective action

LEARNING ACTIVITIES

1. Discuss safety procedures to follow.
2. Explain how to obtain correct temperature to set oven.
3. Demonstrate quenching procedures.
4. Explain how to operate and read the Rockwell hardness tester.
5. Discuss the quenching bath.
6. Explain the air cooling process.
7. Discuss the importance of a clean work area.

RESOURCES

Krar, et. al. **Technology of Machine Tools**, pp. 404, 414-415.
McCarthy and Repp. **Machine Tool Technology**, pp. 557.
Lascoe, et. al. **Machine Shop Operations and Setups**, 3rd ed., p. 418.

EVALUATION

Written Questions

1. List the steps involved in hardening steel.
2. What determines the degree of hardness obtainable in alloy steels through heat treatment?
3. List three hardness number systems.
4. What are the most commonly used Rockwell hardness scales?

Answers

1. Steps 2 through 6 in Performance Guide.
2. The percentage of carbon in steel not to exceed 1.5%.
3. a. Rockwell hardness sale
   b. Brinell
   c. Shore scleroscope
4. "B" and "C"

DUTY: PERFORMING HEAT TREATMENT TASKS

TASK: Anneal workpiece

PERFORMANCE OBJECTIVE V-TECS 190

STANDARD: Workpiece must be annealed so a file will cut it.

SOURCE OF STANDARD: Oberg, et. al. **Machinery's Handbook**, pp. 2135-2139, 2152, 2162.

CONDITIONS FOR PERFORMANCE OF TASK:
Heat treat oven with accessories
Hardened carbon steel workpiece
Specifications
Machinist's handbook
File
Tongs

PERFORMANCE GUIDE

1. Place workpiece in heat treat oven with tongs
2. Select and set oven temperature (see handbook or reference for annealing temperature)
3. Start oven
4. Heat workpiece uniformly to required temperature
5. Soak workpiece at temperature one hour per inch of thickness
6. Turn off oven
7. Allow workpiece to cool in oven (remove with tongs)
8. Test workpiece with corner of file
   a. Accept workpiece as annealed, or
   b. Reject workpiece and/or recommend corrective action

LEARNING ACTIVITIES

1. Discuss safety procedures to follow.
2. Discuss and demonstrate the setting of thermostats.
3. Demonstrate correct procedure to start oven.
4. Explain how to obtain correct temperature.
5. Explain how to remove workpiece and shut off oven.
6. Demonstrate how to test workpiece.
7. Discuss reading assignment on heat treating.

RESOURCES

Krar, et. al. **Technology of Machine Tools**, pp. 405, 410.
McCarthy and Repp. **Machine Tool Technology**, p. 554.
Lascoe, et. al. **Machine Shop Operations and Setups**, 3rd ed., pp. 416, 423.

EVALUATION

Written Questions

1. What is the purpose for annealing?
2. Explain the full annealing process for medium carbon steel.

Answers

1. To restore metal to original stage.
2. Steps 4 through 7 in Performance Guide.

DUTY: PERFORMING HEAT TREATMENT TASKS

TASK: Stress draw workpiece

PERFORMANCE OBJECTIVE V-TECS 192

STANDARD: Workpiece must be stress drawn according to machinist's handbook specifications.

SOURCE OF STANDARD: Oberg, et. al. **Machinery's Handbook**, pp. 2162-2165.

CONDITIONS FOR PERFORMANCE OF TASK:
Heat treat oven
Tongs
Gloves
Stressed workpiece
References
Machinist's handbook

PERFORMANCE GUIDE

1. Check workpiece material and thickness
2. Set oven temperature at normalizing temperature
3. Place workpiece on oven with tongs
4. Heat workpiece to required temperature
5. Remove workpiece with tongs after uniformly heated
6. Cool workpiece in air
7. Recommend workpiece stress drawn according to machinist's handbook specifications

LEARNING ACTIVITIES

1. Discuss safety procedures to follow.
2. Illustrate the reasons for stress by drawing a workpiece.
3. Show how to obtain the correct temperature.
4. Demonstrate testing procedure.
5. Discuss and demonstrate cooling procedures.
6. Discuss the importance of a clean work area.

RESOURCES

Krar, et. al. **Technology of Machine Tools**, pp. 404-405, 418.
McCarthy and Repp. **Machine Tool Technology**, p. 549.
Lascoe, et. al. **Machine Shop Operations and Setups**, p. 423.

EVALUATION

Written Questions

1. What is meant by stress?
2. List three general types of stress which may be applied to a structural member.

Answers

1. Internal strain or tension, displacing molecules by contraction or compaction.
2.
   a. Compression
   b. Tensil
   c. Rigidity

N/C MACHINES

DUTY: OPERATING NUMERICAL CONTROLLED MACHINES

TASK: Calculate coordinates and dimensions of numerical control drawing

PERFORMANCE OBJECTIVE V-TECS 193

STANDARD: Dimensions must meet blueprint specifications and be within a tolerance of ± 0.001".

SOURCE OF STANDARD: Kibbe, et. al. **Machine Tool Practices**, pp. 855-860.

CONDITIONS FOR PERFORMANCE OF TASK:
Numerically controlled milling machine
Machinist's handbook
References
Calculator
Blueprint

PERFORMANCE GUIDE

1. Identify type of spindle positioning
   a. Incremental measurement or
   b. Absolute or coordinate measurement
2. Interpret blueprint data to
   a. Check number of holes same size
   b. Check number of holes requiring same operation
3. Establish starting or absolute zero point
   a. Corner of workpiece
   b. Off workpiece for tool changes
4. Convert all dimensions including angles to decimal dimensions
5. Calculate dimensions from two adjacent sides as from zero point
6. Verify calculations as within tolerance by adding plus (+) and minus (-) dimensions in each axis
   a. Accept calculations, or
   b. Reject calculations and correct error(s) until calculations are within tolerance

LEARNING ACTIVITIES

1. Describe and discuss incremental and absolute measurement.
2. Review blueprint data.
3. Explain and demonstrate the use of zero point.
4. Demonstrate the need to change all dimensions to decimals.
5. Demonstrate how to verify calculations.
6. Demonstrate tool change position.

RESOURCES

Lascoe, et. al. **Machine Shop Operations and Setups**, pp. 448-464.
Krar, et. al. **Technology of Machine Tools**, pp. 458-466.
McCarthy and Repp. **Machine Tool Technology**, pp. 480-495.

EVALUATION

Written Questions

1. Explain the difference between absolute and incremental dimensioning.
2. Explain the difference between the part reference point and the machine table reference point. From which point must all tool movements be measured?
3. In incremental programming, what symbol is used to indicate a move in the negative direction?

Answers

1. Absolute dimensioning is a dimension expressed with respect to origin of a co-ordinate system.
2. a. The machine reference point is the position the tool returns after a complete cycle. The part reference point is the position the part is located for the first machining operation.
   b. The machine reference point.
3. (-x)

DUTY: PERFORMING NUMERICAL CONTROLLED MACHINES

TASK: Write program for numerical control

PERFORMANCE OBJECTIVE V-TECS 197

STANDARD: The program must include minimum tool change, return to starting point at end of program, and meet blueprint specifications.

SOURCE OF STANDARD: Olivo. **Fundamentals of Machine Technology**, p. 19.
Kibbe, et. al. **Machine Tool Practices**, p. 855.

CONDITIONS FOR PERFORMANCE OF TASK:
Reference material
Machinist's handbook
N/C machine manual
Blueprint

PERFORMANCE GUIDE

1. Review blueprint
2. Determine fixture to be used
3. Determine sequence of operations
   a. Determine which operations to be performed
   b. Determine order of operations: center drill, drill, tap or ream, etc.
4. Determine tools required
5. Establish starting and finishing point (references)
6. Calculate dimensions not on blueprint
7. Determine tool changes
8. Write program
   a. Note tool changes
   b. Note other instructions
9. Verify program
   a. Plus values and minus values of (x) equals zero
   b. Plus values and minus values of (y) equals zero

LEARNING ACTIVITIES

1. Review and explain the codes of N/C preparator and miscellaneous functions.
2. Review and explain:
   a. Programming format
   b. Information blocks
   c. Sequence number
   d. Feed rate
3. Explain how to determine if a move is positive or negative.
4. Demonstrate how to write a program.
5. Have students write a program and verify it.

RESOURCES

Lascoe, et. al. **Machine Shop Operations and Setups**, pp. 456-460.
Krar, et. al. **Technology of Machine Tools**, p. 464.
McCarthy and Repp. **Machine Tool Technology**, pp. 490-491.

EVALUATION

Written Questions

1. What is the first consideration given when writing a program for numerical controlled machines? Explain.
2. What is always the first step in writing a program?

Answers

1. How the workpiece will be held for machining a setup point should be determined far enough away from the workpiece so that sharp tools do not interfere with loading and unloading the machine.
2. The first line of the program should contain only an EOB code which is necessary for carrying out the rewind stop command given on the next line of the program. The second line of every program should have only a rewind stop code and EOB code.

DUTY: **OPERATING NUMERICAL CONTROLLED MACHINES**

TASK: Transfer numerical control drawing to tape

PERFORMANCE OBJECTIVE V-TECS 196

STANDARD: Tape must meet blueprint specifications.

SOURCE OF STANDARD: Kibbe, et. al. **Machine Tool Practices**, p. 855.

CONDITIONS FOR PERFORMANCE OF TASK:
N/C machine
Machine manual
References
Program sheets
Tape punching machine
Calculator
Blueprint

PERFORMANCE GUIDE

1. Study blueprint
2. Determine sequence of operations
   a. Determine which operations required
   b. Determine tools required
3. Establish starting and finishing point (reference)
4. Calculate required dimensions
5. Determine tool changes
6. Write program on program sheet
   a. Note tool changes
   b. Note other instructions
7. Check program
8. Prepare tape on tape punching machine
9. Run print out of tape
10. Check printout making required corrections

LEARNING ACTIVITIES

1. Explain the use of tape writer.
2. Demonstrate functions on keyboard.
3. Identify the setting up and starting procedures.
4. Demonstrate by punching tape.
5. Explain and discuss how to care for machine and tapes.

RESOURCES

Lascoe, et. al. **Machine Shop Operations and Setups**, p. 460.
Krar, et. al. **Technology of Machine Tools**, p. 464.
McCarthy and Repp. **Machine Tool Technology**, p. 491.
Numerical Controlled Machine Manual

EVALUATION

Written Questions

1. Give the steps or procedure for transferring the drawing to tape for the numerical controlled machine.
2. What purpose is G-code numbers used in N/C programming?

Answers

1. a. Study engineering drawing to determine best sequence of machining operations.
   b. Determine location of part of fixture in relation to zero reference point on machine table.
   c. Determine coordinate points.
   d. Determine tool selection, cutting speed and feed rates.
   e. Write program manuscript.
   f. Punch and verify tape for accuracy.
2. G-code numbers are used to signal the N/C machine that a particular mode of operation is required.

DUTY: OPERATING NUMERICAL CONTROLLED MACHINES

TASK: Set up a numerical control machine

PERFORMANCE OBJECTIVE V-TECS 195

STANDARD: The workpiece must be within a tolerance of ± 0.001" and/or meet blueprint specifications.

SOURCE OF STANDARD: Kibbe, et. al. **Machine Tool Practices**, pp. 867-870.

CONDITIONS FOR PERFORMANCE OF TASK:

N/C milling machine
Tape reader
Tape
Tool program
Drills
Reamers
Cutters
Tool holders
Wrenches
Work-holding device
Machinist's handbook
Operator's manual
Dial indicator
Edge finder
Blueprint

PERFORMANCE GUIDE

1. Review blueprint and operator's manual
2. Mount workpiece in work-holding device
3. Center spindle over zero point with edge finder and dial indicator (note dial readings)
4. Place tape in tape reader
5. Mount tool in toolholder (check amount of projection)
6. Run table clear of workpiece and set depth stop
7. Return table to start and observe first block run on tape with table lowered
8. Make required corrections
9. Repeat steps 5-8 with each block and change of tool
10. Check return to zero point after machining workpiece
11. Verify workpiece within tolerances
12. Make required adjustments until machined workpiece is within specifications

LEARNING ACTIVITIES

1. Discuss all safety rules and procedures.
2. Explain the importance of mounting workpiece on machine.
3. Describe and demonstrate how to locate spindle over zero point.
4. Determine and demonstrate how to set speed.
5. Demonstrate how to mount tools.
6. Demonstrate how to lower table and have students observe first block run.

RESOURCES

Lascoe, et. al. **Machine Shop Operations and Setups**, pp. 462-463.
Krar, et. al. **Technology of Machine Tools**, p. 464.
McCarthy and Repp. **Machine Tool Technology**, p. 494.
Numerical Controlled Machine Manual

EVALUATION

Written Questions

1. What is the most important rule when setting up a numerical controlled machine for machining?
2. Give the procedure for checking the machine before starting the first cut.

Answers

1. Always position workpiece on table in relation to zero point or home base on machine table.
2. a. Set all tools in position, if cutting multiple or different sized holes in workpiece.
   b. Make a trial or "dry run" through the complete cycle before allowing tool to touch workpiece.
   c. After trial run, position cutting tools in head and proceed with machining operation.
   d. Check first sequence of machining for accuracy. Re-adjust tool if necessary.

DUTY: OPERATING NUMERICAL CONTROLLED MACHINES

TASK: Machine workpiece with numerical controlled machine

PERFORMANCE OBJECTIVE V-TECS 194

STANDARD: Workpiece must meet blueprint specifications and be within a tolerance of ± 0.001" on decimal dimensions and ± 1/64" on fraction dimensions.

SOURCE OF STANDARD: Kibbe, et. al. **Machine Tool Practices**, pp. 867-870.

CONDITIONS FOR PERFORMANCE OF TASK:

Numerically controlled milling machine
Tape
Tool program
Tools
Tool holders
Work-holding device
Tape reader
Operator's manual
Vernier calipers
Steel rule
Gages

PERFORMANCE GUIDE

1. Review operator's manual
2. Review blueprint
3. Review tool program
4. Check tools for sharpness or damage
5. Mount workpiece in work-holding device
6. Mount first tool in spindle
7. Place tape in reader and start reader
8. Machine workpiece
    a. Monitor for tool changes
    b. Monitor for depth stops changes
    c. Monitor for start/or stop coolant
9. Remove workpiece and deburr
10. Verify workpiece within or without designated tolerances
    a. Accept workpiece, or
    b. Reject workpiece and/or take corrective action

LEARNING ACTIVITIES

1. Discuss all safety rules and procedures.
2. Demonstrate how to setup tape reader.
3. Demonstrate how to monitor for tool changes.
4. Explain and demonstrate how to prepare machine to start program.
5. Demonstrate how to machine workpiece, change tools, and change workpiece.

RESOURCES

Lascoe, et. al. **Machine Shop Operations and Setups**, pp. 462-464.
Krar, et. al. **Technology of Machine Tools**, p. 464.
McCarthy and Repp. **Machine Tool Technology**, p. 494.
Numerical Controlled Machine Manual

EVALUATION

Written Questions

1. Name at least two reasons that would cause workpiece to be out of tolerance even though the program is correct in numerical controll machine.
2. Give the potential advantages of using N/C machines.

Answers

1. a. Dull, worn or abused tools or tool holders
   b. Incorrect feeds and speeds of machine.
   c. Wrong coolant, or lack of coolant can cause excessive heat buildup due to faster feeds and speeds of the N/C machine over conventional machines.
2. a. Accuracy of parts, standard making of part at a faster pace means more production for less expenses.
   b. Tape can be used for repeat orders for same parts, therefore eliminating costly jigs and fixtures each time.

APPENDICES

APPENDIX A

DEFINITION OF TERMS

The following terms are supplied to establish operational definitions as they apply to this study.

CAREER LADDER: A vertical arrangement of jobs within an occupational area to indicate skill distinction and progression.

CATALOGS: A comprehensive collection of performance objectives, performance guides, criterion-referenced measures, and related data organized by a job structure or career ladder within a domain of interest.

CONSORTIUM: A group of state agencies, institutions, or other entities which has been legally constituted through letters of commitment, agreements, or by assignment of higher authorities to work together toward the solution of problems in education. A membership from autonomous agencies and institutions which cuts across state boundaries as it attempts to solve problems or meet goals.

D.O.T. CODE: A nine-digit number used to identify a specific job within a given domain.

INSTRUCTIONAL SYSTEM DEVELOPMENT (ISD): A deliberate, orderly process for planning and developing instructional programs which insures that personnel are taught the knowledge, skills, and attitudes essential for successful job performance. Depends on a description and analysis of the tasks necessary for performing the job, objectives, evaluation procedures to determine whether or not the objectives have been reached, and methods for revising the process based on empirical data.

OCCUPATIONAL INVENTORY (TASK INVENTORY BOOKLET): A survey instrument containing tasks performed by job incumbents within D.O.T.'s complete with background information and a list of tools and equipment.

PERFORMANCE-BASED INSTRUCTION: Instruction which, when properly designed and applied, results in the learner's demonstration of certain abilities. The desired abilities are selected before the instruction is designed and are clearly defined as observable performance objectives. In V-TECS catalogs, the abilities are primarily psychomotor. This type of instruction is also referred to as competency-based instruction.

PERFORMANCE GUIDE (PG): A series of steps, arranged in a sequence ordinarily followed, which when completed may result in the performance of a task. Also, called "teaching steps."

PROJECT: An occupational domain area selected by a V-TECS member state for catalog; development based upon the U.S. Department of Labor's Dictionary of Occupational Titles (D.O.T.).

STATE-OF-THE-ART (SOA STUDY): Research conducted to determine the current status of performance-based instructional materials and practices in the domain area under study and to obtain other information that might be useful in catalog development.

TASK: A unit of work activity which constitutes logical and necessary steps in the performance of a duty. A task has a definite beginning and ending point in its accomplishments and generally consists of two or more definite steps.

TASK ANALYSIS: A characteristic of a task statement which makes its accomplishments crucial to the acceptable performance of a worker or student. A method of analysis which identifies the critical tasks and aids in determining the consequence of poor performance or lack of performance by the worker or student.

WRITING TEAM: A team of people representing instructors within subject matter expertise, persons having knowledge and experience in developing criterion-referenced measures, and local or state supervisors of incumbent workers whose function is to analyze occupational data and develop performance objectives and criterion-reference measures for specific D.O.T. areas.

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APPENDIX B

DUTIES AND TASKS

	Duty and Task	Performance Objective/ Page Number
I.	Safety	
	Identify safety rules and regulations in the machine shop	SC-1/5
II.	Performing Mathematical Calculations	
	Calculate feeds and speeds	V-TECS-60/9
	Convert fraction dimension to decimal dimension	V-TECS-67/11
	Calculate amount of stock required in machine work	V-TECS-57/13
	Calculate tapers for machine set-up	V-TECS-65/18
	Calculate gear blank specifications	V-TECS-62/20
	Calculate tap drill size with formula	V-TECS-64/23
	Calculate conversions of revolutions per minute (RPM) of grinding wheel to surface feet per minute (SFPM)	V-TECS-58/25
	Calculate for angular and simple indexing	V-TECS-61/26
	Calculate tolerances or allowances	V-TECS-66/28
	Calculate depths and widths of slots and grooves on special set ups	V-TECS-59/30
III.	Designing and Planning Machine Work	
	Interpret and sketch multi-view drawings	SC-2/32
	Make sketches of work to be machined	V-TECS-1/34
	Apply company standards	SC-3/38
IV.	Performing Precision Measurement	
	Care for precision instruments	V-TECS-2/40
	Measure work with tape measure	V-TECS-24/42
	Measure work with 6" pocket rule	V-TECS-22/43
	Measure work with slide caliper rule	V-TECS-21/44
	Layout work with combination square	V-TECS-10/45
	Measure work with spring caliper	V-TECS-23/47
	Layout work with hermaphrodite calipers	V-TECS-11/48
	Check work with radius gages	V-TECS-6/50
	Measure work with outside micrometer	V-TECS-20/51
	Measure work with inside micrometer	V-TECS-19/53
	Measure work with thread wires	V-TECS-26/55
	Measure work with depth gages	V-TECS-13/57
	Measure work with depth micrometer	V-TECS-14/59
	Measure inside and outside diameter with vernier caliper	V-TECS-12/61
	Check work with optical comparator	V-TECS-4/63
	Check work with sine bar	V-TECS-7/65

Performing Precision Measurement continued:

Measure work with gage blocks	V-TECS-16/67
Layout work on surface plate	V-TECS-8/69
Measure work on surface plate	V-TECS-3/71
Check work with surface gage	V-TECS-9/73
Measure work with indicators and attachments	V-TECS-18/74
Measure work with height gages	V-TECS-17/76
Check work with plug and ring gages	V-TECS-5/78
Measure work with telescope and hole gages	V-TECS-25/80
Measure work with dial calipers	V-TECS-15/82

V. Performing Benchwork

Inspect work area for safe working environment	V-TECS-38/84
Care for hand tools	V-TECS-30/88
Cut material with hand hacksaw	V-TECS-31/90
Bench file workpiece	V-TECS-28/91
Mark location with prick punch and center punch	V-TECS-42/93
Drill holes with portable drill	V-TECS-33/95
Cut threads with hand tap	V-TECS-32/97
Cut threads with die	V-TECS-56/99
Ream holes with hand reamers	V-TECS-44/101
Work and shape metal with handheld tools	V-TECS-55/103
Test workpiece with hardness tester	V-TECS-54/105
Test workpiece for hardness without hardness tester	V-TECS-53/107
Polish metal	V-TECS-43/108
Grind part with hand grinder	V-TECS-34/110
Broach workpiece with broaching tool	V-TECS-29/112
Locate holes with transfer screws and transfer punches	V-TECS-41/113
Remove and install dowel pins	V-TECS-45/115
Remove broken drills and taps	V-TECS-46/117
Remove damaged screws	V-TECS-47/119
Remove defective machine parts and replace	V-TECS-48/121
Replace and adjust machine parts	V-TECS-50/123
Scrape bearings and slides	V-TECS-51/125
Straighten workpiece on arbor press	V-TECS-52/127
Remove frozen or seized parts	V-TECS-49/128
Lap surfaces	V-TECS-40/130
Install a helical coil wire insert	V-TECS-39/132
Inspect and change drive pulleys and belts	V-TECS-37/134
Hone workpiece	V-TECS-36/136
Hand whet cutting tools	V-TECS-35/138
Assemble or disassemble work with arbor press	V-TECS-27/139

VI. Operating Drill Presses

Clean and lubricate drill press	V-TECS-69/142
Drill hole to size	V-TECS-72/143
Countersink hole to specifications	V-TECS-71/145
Counterbore hole to specifications	V-TECS-70/147
Spotface to specified dimensions	V-TECS-80/149
Drill hole with automatic feed	V-TECS-73/151
Drill workpiece with drill jigs	V-TECS-74/152
Lap hole to size	V-TECS-75/154
Mount work on V-blocks	V-TECS-76/155
Ream hole to size	V-TECS-77/157
Sharpen drill free hand	V-TECS-78/159
Sharpen drill with grinding attachment	V-TECS-79/161
Tap hole by hand on drill press	V-TECS-81/163
Tap hole with tapping attachment	V-TECS-82/165

VII. Operating Grinders

Clean and lubricate grinders	V-TECS-85/168
Balance grinding wheel	V-TECS-83/170
Dress and true grinding wheels on pedestal grinder	V-TECS-87/172
Grind and shape chisels and hand tools on pedestal grinder	V-TECS-89/174
Grind and sharpen lathe tools free hand	V-TECS-90/176
Dress and true machine tool grinding wheel	V-TECS-88/178
Grind workpiece square on surface grinder	V-TECS-99/180
Grind workpiece on magnetic chuck using power feed	V-TECS-98/182
Grinding workpiece lined up with indicator	V-TECS-97/184
Grind radii and angles on surface grinder	V-TECS-95/186
Polish with grinding machine	V-TECS-84/188
Grind workpiece between centers	V-TECS-96/189
Cut off or part material with grinding wheels	V-TECS-86/191

VIII. Operating Power Saws

Clean and lubricate power saws	V-TECS-102/194
Select and set speeds and feeds for sawing operations	V-TECS-108/196
Cut and weld bandsaw blade	V-TECS-103/198
Cut material to length with power hack saw	V-TECS-104/200
Replace saw blades	V-TECS-105/202
Saw internal contours-band saw	V-TECS-106/205
Saw to scribed line	V-TECS-107/207

IX. Operating Lathes

Clean and lubricate lathes	V-TECS-116/210
Face workpiece	V-TECS-128/212
Set lathe speed and rough cut workpiece	V-TECS-139/214
Set lathe speed and finish cut workpiece	V-TECS-138/215
Perform lathe filing	V-TECS-129/217
Polish workpiece	V-TECS-130/218
Drill holes with lathe	V-TECS-127/219
Align lathe centers using accurate measurement techniques	V-TECS-109/221
Turn workpiece between centers on the lathe	V-TECS-145/222
Knurl parts with lathe	V-TECS-132/224
Machine part for precision fit	V-TECS-133/226
Align workpiece in four jaw chuck	V-TECS-110/227
Bore holes with lathe	V-TECS-112/229
Countersink holes using lathe	V-TECS-118/231
Counterbore holes using lathe	V-TECS-117/233
Ream holes with lathe	V-TECS-136/234
Tap hole with lathe	V-TECS-143/236
Cut external taper with compound rest	V-TECS-123/238
Cut tapers by offset tailstock	V-TECS-124/240
Cut a long external tapered surface with taper attachment	V-TECS-119/242
Cut internal tapered surfaces with taper attachment	V-TECS-121/244
Die cut threads with lathe, hand threading	V-TECS-125/246
Die cut threads with lathe using die heads	V-TECS-126/248
Make contour cut with lathe	V-TECS-135/250
Swing convex or concave radii from compound swivel	V-TECS-142/252
Chase external threads with the lathe	V-TECS-113/254
Chase internal threads with lathe	V-TECS-114/256
Rechase threads on lathe	V-TECS-137/258
Chase metric threads	V-TECS-115/260
Cut Acme threads	V-TECS-120/262
Cut multiple threads	V-TECS-122/264
Turn or thread long workpieces using follower and steady rest	V-TECS-144/266
Machine part with carbide tools	V-TECS-134/268
Grind workpiece with tool post grinder	V-TECS-131/269
Align workpiece on face plate	V-TECS-111/271
Set up turret lathe for operations	V-TECS-140/273
Spin workpiece on lathe	V-TECS-141/275

X. Operating Milling Machines

Clean, lubricate and adjust milling machine	V-TECS-151/277
Align mill head to table	V-TECS-147/279
Square workpiece using table vise	V-TECS-175/281
Align milling machine attachments	V-TECS-148/283
Align milling machine fixtures with indicator	V-TECS-149/285

Align workpiece mounted on machine table	V-TECS-146/287
Drill holes with milling machine	V-TECS-153/289
Ream holes on mill	V-TECS-174/291
Mill work with end mill	V-TECS-172/293
Locate work with center finder	V-TECS-159/295
Locate work with edgefinder	V-TECS-160/297
Machine work with vertical attachment	V-TECS-166/299
Machine external straight keyway with mill	V-TECS-161/301
Machine work mounted on V-blocks	V-TECS-165/303
Flycut flat surface on mill	V-TECS-155/305
Flycut formed shape on mill	V-TECS-156/307
Form mill workpiece	V-TECS-157/309
Bore holes to tolerance with milling machine	V-TECS-150/311
Jig bore on a milling machine	V-TECS-158/313
Machine Woodruff keyway	V-TECS-163/315
Mill an angular surface	V-TECS-167/317
Mill an external radius with rotary table	V-TECS-168/319
Mill cylindrical work with rotary table	V-TECS-169/321
Mill workpiece using indexing operation	V-TECS-173/323
Mill gears to specifications	V-TECS-170/325
Mill work with carbide cutters	V-TECS-171/328
Machine work by straddle milling	V-TECS-164/330
Cut off work on mill	V-TECS-152/332
Machine internal slots using slotter	V-TECS-162/334
Duplicate on the profile milling machine	V-TECS-154/336

XI. Operating Shapers

Clean and lubricate the shaper	V-TECS-176/339
Select and set speeds and feeds for machining	V-TECS-181/340
Machine flat surface on shaper	V-TECS-179/342
Cut a vertical surface on shaper	V-TECS-177/344
Cut angular surface on shaper	V-TECS-178/346
Machine keyway on shaper	V-TECS-180/348

XII. Welding

Arc weld workpiece in flat position	V-TECS-182/351
Braze workpiece in fixture	V-TECS-183/353
Cut work with cutting torch	V-TECS-184/355
Weld workpiece with oxy-acetylene torch	V-TECS-189/357
Silver solder carbide tools	V-TECS-188/359
Pad shafts with arc welders for machining	V-TECS-187/361
Heliarc weld workpiece in flat position	V-TECS-185/363
Machine workpiece with electro discharge machine (EDM)	V-TECS-186/365

XIII. Performing Heat Treatment Tasks

Harden workpiece	V-TECS-191/368
Anneal workpiece	V-TECS-190/370
Stress draw workpiece	V-TECS-192/372

XIV. Operate Numerical Controlled Machines

Calculate coordinates and dimensions of numerical control drawing	V-TECS-193/374
Write program for numerical control	V-TECS-197/376
Transfer numerical control drawing to tape	V-TECS-196/378
Set up a numerical control machine	V-TECS-195/380
Machine workpiece with numerical controlled machine	V-TECS-194/382

APPENDIX C

EQUIPMENT AND TOOLS BY PERCENTAGE AND NUMBER OF MEMBERS USING

EQUIPMENT/TOOL NUMBER	EQUIPMENT/TOOL DESCRIPTION	PERCENTAGE OF MEMBERS USING	NUMBER OF MEMBERS USING
126	C-Clamps	100.00	71
130	Files	100.00	71
132	Hammer, Ball Pein	100.00	71
144	Tap Wrench	100.00	71
63	Protractor Head	98.59	70
137	Pliers	98.59	70
141	Screwdrivers, Standard	98.59	70
151	Wrenches, Adjustable	98.59	70
38	Dial indicator Holder Adjustable Magnetic	97.18	69
39	Dial Indicator Set	97.18	69
56	Micrometer, Depth	97.18	69
59	Micrometer, Outside	97.18	69
131	Grinding Wheels	97.18	69
114	Countersinks	95.77	68
116	Drills	95.77	68
117	Drill Chuck	95.77	68
135	Parallels	95.77	68
69	Square Head	94.37	67
140	Screwdrivers, Phillips	94.37	67
142	Tap & Die Set	94.37	67
147	Vise, Machinists	94.37	67
35	Center Punch	92.96	66
37	Dial Caliper	92.96	66
99	Cutters, End Mill	92.96	66
112	Center Drill	92.96	66
148	Wheel Dresser, Abrasive	92.96	66
152	Wrenches, Box End	91.55	65
32	Caliper, Vernier	90.14	64
47	Gage, Depth	90.14	64
82	Boring Bar	90.14	64
113	Counterbores	90.14	64
127	Chisels	90.14	64
146	V-Block & Clamp	90.14	64
15	Grinder, Pedestal	88.73	63
52	Gage, Radius	88.73	63
84	Chuck, Universal	88.73	63
97	Cutters, Carbide Face	88.73	63
106	Mill Vise, Standard	88.73	63
139	Punches	88.73	63

EQUIPMENT/TOOL NUMBER	EQUIPMENT/TOOL DESCRIPTION	PERCENTAGE OF MEMBERS USING	NUMBER OF MEMBERS USING
21	Lathe, Engine	87.32	62
29	Caliper, Inside	87.32	62
30	Caliper, Outside	87.32	62
43	Edgefinder	87.32	62
53	Gage, Telescoping	87.32	62
57	Micrometer, Inside	87.32	62
83	Chuck, Independent	87.32	62
90	Lathe Dogs	87.32	62
119	Reamer, Machine	87.32	62
145	Thread Files	87.32	62
153	Wrenches, Socket Set	87.32	62
80	Wiggler	85.92	61
96	Boring Head	85.92	61
122	Angle Plate	85.92	61
24	Milling Machine, Vertical	84.51	60
149	Wheel Dresser, Diamond	84.51	60
88	Knurling Tool	83.10	59
105	Mill Vise, Universal	83.10	59
4	Bandsaw, Vertical	81.69	58
42	Dividers	81.69	58
86	Faceplate, Lathe	81.69	58
93	Lathe Steady Rest	81.69	58
120	Tapping Attachment	81.69	58
54	Gage, Vernier Height	80.28	57
75	Transfer Punches	80.28	57
3	Bandsaw, Horizontal	78.87	56
45	Gage Blocks	78.87	56
71	Surface Gage	78.87	56
72	Surface Plate	78.87	56
143	Tap Extractor	78.87	56
23	Milling Machine, Horizontal	76.06	54
33	Center Gage	76.06	54
65	Screw Pitch Gage	76.06	54
77	Universal Bevel Protractor	76.06	54
94	Lathe Taper Attachment	76.06	54
125	Broach, Keyway	76.06	54
150	Wheel Dresser, Star	76.06	54
17	Grinder, Surface	74.65	53
62	Prick Punch	74.65	53
95	Mandrel, Lathe	74.65	53
102	Cutters, Plain	74.65	53
118	Live Center	74.65	53
6	Disc Sander, Portable	73.24	52
8	Drill Press, Radial	73.24	52
34	Center Head	73.24	52
70	Square, Solid	73.24	52
87	Grinder, Tool Post	73.24	52
89	Lathe Collet Set	73.24	52

EQUIPMENT/TOOL NUMBER	EQUIPMENT/TOOL DESCRIPTION	PERCENTAGE OF MEMBERS USING	NUMBER OF MEMBERS USING
124	Bandsaw Blade Welder	73.24	52
134	Hole Punches	73.24	52
13	Grinder, Carbide Tool Pedestal	71.83	51
16	Grinder, Portable	71.83	51
46	Gage, Center	71.83	51
103	Dividing Head	71.83	51
108	Rotary Table	71.83	51
5	Belt Sander	70.42	50
81	Arbor	70.42	50
98	Cutters, Dovetail	70.42	50
50	Gage, Hole	69.01	49
115	Dead Center	69.01	49
136	Parallel Clamps	69.01	49
44	Gage, B&S Thread Tool	67.61	48
121	Adjustable Parallels	67.61	48
64	Rule Depth Gage	66.20	47
100	Cutters, Form	66.20	47
128	Cutting Torch	66.20	47
7	Drill Press, Automatic Upright	64.79	46
48	Gage, Drill Diameter	64.79	46
49	Gage, Drill Point	64.79	46
40	Diemakers Square	63.38	45
41	Digital Readout	63.38	45
76	Transfer Screws	63.38	45
91	Lathe Follower Rest	63.38	45
55	Hermaphrodite Calipers	61.97	44
61	Micrometer, Vernier	57.75	41
66	Sine Bar	57.75	41
74	Thread Tool Gage, Acme	57.75	41
92	Lathe Micrometer Stop	56.34	40
129	Drill Grinding Attachment	56.34	40
1	Acetylene-Oxygen Weld. Outfit	54.93	39
31	Caliper Rule	54.93	39
2	Arc Welder	53.52	38
78	Vernier Depth Gage	53.52	38
14	Grinder, Cylindrical	49.30	35
28	Tester, Hardness	49.30	35
111	Vertical Milling Attachment	47.89	34
138	Punch Block	47.89	34
19	Hacksaw, Power	46.48	33
67	Sine Plate, Adjustable	46.48	33
110	Universal Milling Attachment	45.07	32
9	Drill Press, Sensitive	42.25	30
22	Lathe, Turret	42.25	30
27	Shaper	42.25	30
123	Anvil	42.25	30
18	Grinder, Tool and Cutter	40.85	29
85	Die Head	39.44	28

EQUIPMENT/TOOL NUMBER	EQUIPMENT/TOOL DESCRIPTION	PERCENTAGE OF MEMBERS USING	NUMBER OF MEMBERS USING
60	Micrometer, Thread	36.62	26
101	Cutters, Gear	36.62	26
133	Hammer, Pin Head	30.99	22
68	Sine Plate, Magnetic	29.58	21
51	Gage, Planer and Shaper	28.17	20
12	Furnace, Heat Treat	26.76	19
25	Numerical Controlled Mill	26.76	19
58	Micrometer, Metric	26.76	19
109	Slotting Attachment	26.76	19
36	Comparator, Optical	25.35	18
20	Heliarc Welder	23.94	17
26	Planer	21.13	15
73	Test Bar	19.72	14
11	Filing Machine	18.31	13
79	Vernier Gear Tooth Caliper	18.31	13
10	Electro-Discharge Machine	15.49	11
104	Gear Cutting Attachment	15.49	11
107	Rack Milling Attachment	14.08	10
154	Wrenches, Allen	1.41	1
155	Wrench, Speed	1.41	1
156	Drill, Hand Electric	1.41	1
157	Bearing Puller	1.41	1
158	Plumb Bob	1.41	1
159	Level, Precision	1.41	1
160	Press, Hand	1.41	1
161	Winder, Spring	1.41	1
162	Cam Cutter, Mill Attachment	1.41	1
163	Spline Cutter, Mill Attachment	1.41	1
164	Gage, Dial Bore	1.41	1

TOOLS AND EQUIPMENT ADDED BY CONSENSUS OF WRITING TEAM*

EQUIPMENT/TOOL NUMBER	EQUIPMENT/TOOL DESCRIPTION
165	Gage, Pin
166	Lathe, Tool Room
167	Micrometer, Indicating
168	Hone, Cylinder
169	Lathe, Tracer
170	Tool, Thread Cutting
171	Tools, Cut Off
172	Dresser, Radius Wheel
173	Gages, Leaf

*V-TECS Catalog Writing Team, State of Kentucky.

EQUIPMENT/TOOL NUMBER	EQUIPMENT/TOOL DESCRIPTION
174	Square, Column
175	Welder, Micro-Wire
176	Trammel
177	Scrapers
178	Tool, Hand Burring
179	Milling Attachment, Spiral
180	Letter Stamps
181	Hacksaw, Hand
182	Calculator
183	Rawhide Mallet
184	Grinder, Pedestal Drill
185	Wrench, Torque
186	Press, Hydraulic
187	Gage, Groove
188	Indicator, Co-Axial

APPENDIX D

WRITTEN QUESTIONS FOR EVALUATION

I. Safety

SC-1 1. Name at least six safety rules and regulations to be followed in the machine shop.

SC-1 2. Complete at least one of the safety tests with 100% accuracy. (Tests are located with the lesson.)

II. Performing Mathematical Calculations

V-TECS 60 3. Give the formulas for (a) calculating cutting speed and (b) calculating feed.

V-TECS 67 4. Convert the following common fractions to decimal fractions to an accuracy of ± 0.001" using conversion chart as guide.

  a. 11/16 =
  b. 1/8 =
  c. 19/32 =
  d. 5/16 =
  e. 3/32 =

V-TECS 57 5. From the attached blueprint and the following inventory of stock (scrap pile and metal rack), complete a Bill of Materials without error. 1 piece 1 1/4" x 5/8" flat steel 6 1/4" long
Note: Stock has to be the size stated above to allow for machining. (Blueprint located with the lesson)

V-TECS 65 6. To complete tapers for machine set up, give formulas for taper per inch and taper per foot.

V-TECS 65 7. What is the formula for offsetting tailstock to give desired taper?

V-TECS 62 8. Give the formulas for cutting a gear from a blank:

  a. Outside diameter of gear blank
  b. Depth of tooth
  c. Tooth thickness
  d. Calculate addendum
  e. Chordal addendum
  f. Chordal thickness

V-TECS 64 9. For a hole 3/4 " in diameter, ten threads per inch and 80% thread depth, calculate tap drill size using the formula:

$$\text{Hole size} = \frac{.0129 \times \% \text{ of thread}}{\text{Number of threads per inch}}$$

V-TECS 58 10. What is the surface speed per minute of a wheel 8" in diameter turning 5000 rpm?

V-TECS 61 11. What are the two most common dividing heads in use today?

V-TECS 61 12. Explain simple indexing.

V-TECS 66 13. Define the meaning of the term tolerance.

V-TECS 66 14. Define the meaning of the term allowance.

V-TECS 59 15. What are the two most commonly used instruments used in measuring slots and grooves?

V-TECS 59 16. Where is the starting point of the cut when cutting a splined shaft?

III. Designing and Planning Machine Work

SC-2	17.	Draw a multi-view sketch of a machine object showing the three-dimensional view of the object. (Sketch is located with lesson.)
V-TECS 1	18.	On the attached blueprint sketch: (1) Compute the missing dimensions (2) explain the meaning and purpose of the footnotes. (Blueprint is located with lesson.)
V-TECS 1	19.	Why are written and verbal instructions important when working from sketches or blueprints?
V-TECS 1	20.	Give the symbols for external and internal threads and for finished surfaces.
SC-3	21.	Name at least three steps taken in the application of company standards in designing and jplanning machine work.

IV. Performing Precision Measurement

V-TECS 2	22.	Name at least five steps in caring for precision instruments.
V-TECS 24	23.	Tape measures are considered ______________ measuring instruments. (Fill in the blank)
V-TECS 22	24.	Define parallax error.
V-TECS 22	25.	Why is it good practice not to measure to end of rules?
V-TECS 21	26.	What advantage does the slide caliper rule have over the 6" rule?
V-TECS 10	27.	Why must a precision square not be used as a working square?
V-TECS 10	28.	Name the four parts of a combination square.
V-TECS 23	29.	Compare accuracy of spring calipers to dial calipers.
V-TECS 11	30.	The layout tool that has one leg shaped like a caliper, the other leg is pointed like a divider is called ______________ ______________. (Fill in the blank)
V-TECS 6	31.	List two uses for radius gages.
V-TECS 20	32.	Describe briefly the principle of the vernier micrometer.
V-TECS 20	33.	Describe the procedure for reading a vernier micrometer.
V-TECS 20	34.	Explain how a 2" micrometer may be checked for accuracy.
V-TECS 20	35.	What are the basic differences between a metric and an inch micrometer?
V-TECS 20	36.	What is the value of one division on: (Using metric micrometer) a. The sleeve above the index line b. The sleeve below the index line c. The thimble
V-TECS 19	37.	What construction feature compensates for a lock nut on inside micrometers?
V-TECS 19	38.	What precautions must be taken when: a. Assembling the inside micrometer and extension rod? b. Using the inside micrometer?
V-TECS 19	39.	What is the correct "feel" with an inside micrometer?
V-TECS 26	40.	What is meant by "best" wire size?
V-TECS 26	41.	Calculate the best wire size and the measurement over the wires for a thread 3/4 - 10 NC.
V-TECS 13	42.	Compare accuracy of vernier depth gage to rule depth gage.
V-TECS 14	43.	How is the accuracy of a micrometer depth gauge adjusted?
V-TECS 14	44.	How must the workpiece be prepared prior to measuring the depth of a hole or slot with a micrometer depth gage?

V-TECS 14	45.	Explain the procedure for measuring a depth with a depth micrometer.
V-TECS 14	46.	How does the reading of a depth micrometer differ from that of a standard outside micrometer?
V-TECS 12	47.	Describe the principle of: (a) the 25-division vernier; (b) the 50-division vernier.
V-TECS 12	48.	Describe the procedure for reading a vernier caliper.
V-TECS 4	49.	Define an optical comparator.
V-TECS 4	50.	Why is high amplification necessary in any comparison measurement process?
V-TECS 4	51.	List the advantages of an optical comparator.
V-TECS 4	52.	What precautions are necessary when charts are used on an optical comparator?
V-TECS 7	53.	Describe the construction and principle of a sine bar.
V-TECS 7	54.	What are the accuracies of the 5" and the 10" sine bars?
V-TECS 7	55.	Calculate the gauge block buildup for a 30° angle.
V-TECS 7	56.	In calculating the angle of a taper, why is the formula $\mathrm{Tan}\,\frac{1}{2}\,a = \frac{TPF}{24}$ used, rather than $\mathrm{Tan}\,a = \frac{TPF}{12}$? Illustrate with a suitable sketch.
V-TECS 16	57.	How are gauge blocks stabilized and why is this necessary?
V-TECS 16	58.	State five general uses for gauge blocks.
V-TECS 16	59.	For what purpose are wear blocks used?
V-TECS 16	60.	How should wear blocks always be assembled into a buildup?
V-TECS 16	61.	State the difference between a master set and a working set of gauge blocks.
V-TECS 16	62.	What precautions are necessary when handling gauge blocks in order that the effect of heat on the blocks is minimal?
V-TECS 16	63.	What precautions are necessary for the proper care of gauge blocks.
V-TECS 8	64.	What is the purpose of a surface plate?
V-TECS 8	65.	Name three types of granite used in making surface plates.
V-TECS 8	66.	State five advantages of granite over cast-iron surface plates.
V-TECS 8	67.	List five points necessary for the care of surface plates.
V-TECS 3	68.	How is the accuracy of surfae plates usually indicated?
V-TECS 3	69.	Which is more accurate surface gage or height gage? Why?
V-TECS 9	70.	How are measurements made with surface gage?
V-TECS 18	71.	What is the difference between a dial indicator and a dial test indicator?
V-TECS 18	72.	How may the limits of dimensions be shown on a dial indicator?
V-TECS 18	73.	Compare a perpendicular dial indicator with a universal dial test indicator.
V-TECS 18	74.	State how the accuracy of a dial indicator may be checked.
V-TECS 17	75.	State the two main applications for the vernier height gauge.
V-tECS 17	76.	What accessories are required for a vernier height gauge to check the height of a workpiece accurately?

V-TECS 17 77. A casting with a machined base is placed on a surface plate to check the accuracy of the hole locations. A plug of the proper diameter is inserted in each hole and a dial indicator gauge mounted on a vernier height gauge is set to a 1" gauge block. The following readings were obtained from the top of each plug.

	Hole Diameter	Reading Obtained	Blueprint Reading
a)	.750	4.360	2.945 ± .005
b)	.500	8.009	6.760 ± .002
c)	.450	8.655	7.432 ± .002
d)	.978	3.275	1.782 ± .002
e)	1.000	6.338	4.831 ± .005

V-TECS 17 Calculate the height of the center of each hole and determine which holes are not in location.

V-TECS 17 78. What are the advantages of using a precision height gauge in lieu of a gauge block buildup?

V-TECS 17 79. What dimension(s) must be subtracted from the reading so that the correct reading for the height of a hole being checked will be obtained.

V-TECS 5 80. What purpose do fixed gauges serve in industry?

V-TECS 5 81. To what tolerance are fixed gauges finished?

V-TECS 5 82. If a hole size is to be maintained at 1.750 ± .002, what would be the sizes of the "GO" and "NO-GO" gauges?

V-TECS 5 83. How are the "GO" and "NO-GO" ends of a cylindrical plug gage identified?

V-TECS 5 84. What precautions must be observed when a cylindrical plug gage is used?

V-TECS 25 85. List the steps required to measure a hole with a telescope gauge.

V-TECS 25 86. What hole defects may be conveniently measured with a dial bore gage?

V-TECS 15 87. What is the smallest graduation on dial calipers?

V. Performing Benchwork

V-TECS 38 88. Name at least four items for personal protection as a safety precaution when operating equipment.

V-TECS 38 89. Why should unsafe conditions be reported immediately?

V-TECS 30 90. Name two major points to remember in caring for hand tools.

V-TECS 31 91. What pitch hack saw blade should be selected to cut:

a. Tool steel
b. Thin wall tubing
c. Angle iron and copper

V-TECS 28 92. Name the most commonly used degrees of coarseness in which files are manufactured.

V-TECS 28 93. How can "pinning" of file be kept to a minimum?

V-TECS 28 94. List four points to be observed in caring for files.

V-TECS 42 95. How does a prick punch differ from a center punch?

V-TECS 33 96. Give two safety rules when using hand held electrical drill.

V-TECS 32 97. Define "tap drill" as used in tapping.

V-TECS 32 98. Give the names of taps that make up a "set" of three.

V-TECS 56 99. The __________ __________ __________ has an adjusting screw which permits adjusting over and under size threads. (Fill in the blanks)

V-TECS 44 100. Why should reamers be turned the same way going in and coming out?

V-TECS 55 101. Give two safety rules for using air grinders.

V-TECS 54 102. How does Rockwell hardness tester measure hardness?

V-TECS 53 103. How may hardness be determined by using a file?

V-TECS 43 104. Why should an abrasive back used on band saw machine require a back support?

V-TECS 34 105. Name two important safety rules operators should adhere to while using hand grinders.

V-TECS 29 106. What is an advantage of broaching?

V-TECS 41 107. What is the advantage of using transfer punches and screws?

V-TECS 45 108. What tool is used to make the holes tapered when installing tapered pins?

V-TECS 46 109. What is the advantage of using the EDM in removing broken taps?

V-TECS 47 110. Why is it important to determine whether the screw has right or left hand threads when removing damaged screws?

V-TECS 48 111. Why is it important to refer to manufacturer's manual?

V-TECS 50 112. Why should machines on which parts have been replaced be run on low speed initially?

V-TECS 51 113. What purpose does the Prussian blue serve in scraping bearings and slides?

V-TECS 52 114. Which dial indicator would work best in straightening workpiece?

V-TECS 49 115. Why must hardened parts, such as taps, be annealed before drilling?

V-TECS 40 116. What effect does using a "figure 8" lapping pattern have on workpiece?

V-TECS 39 117. What is the main purpose of helical coil inserts?

V-TECS 37 118. Give at least one reason for not removing a pulley by hitting with hammer.

V-TECS 36 119. How can operators prevent honing too much or cause tapering?

V-TECS 35 120. Why must oil or water be applied to whet stone during sharpening?

V-TECS 27 121. Explain the basic operation of the arbor press.

VI. Operating Drill Presses

V-TECS 69 122. Why should the surface of the table of the drill press be cleaned?

V-TECS 69 123. What are some cleaning materials to be used to clean the drill press?

V-TECS 72 124. What is the decimal equivalent of the fraction drill 1/2 inch?

V-TECS 71 125. What is the purpose of countersinking?

V-TECS 71 126. What is the angle in degrees between the two cutting edges or the angled edges of the countersink?

V-TECS 70 127. What is the purpose of a counterbore?

V-TECS 80 128. Explain spotfacing.

V-TECS 80 129. Give list of tools to be used in spotfacing.

V-TECS 73	130.	When is the drill press with automatic feed lubricated?
V-TECS 74	131.	Give definition of drill jig.
V-TECS 74	132.	Give at least one use of drill jig.
V-TECS 75	133.	What is meant by lapping a hole to size?
V-TECS 76	134.	What type stock are V-blocks used to hold?
V-TECS 76	135.	When and why are V-blocks used?
V-TECS 77	136.	Define reaming.
V-TECS 77	137.	How do you tell the difference between a hand reamer and a power reamer?
V-TECS 77	138.	How are reamers classified?
V-TECS 78	139.	Why should cutting edges of the drills be equal in length?
V-TECS 78	140.	Why is it necessary to thin the web on some drills?
V-TECS 78	141.	Why should cutting edges of the drill be the same angles?
V-TECS 79	142.	Name two methods of grinding twist drills.
V-TECS 79	143.	How do you check the amount of lip clearance when sharpening drill with grinding attachment?
V-TECS 81	144.	Give the names of two tools used for hand tapping.
V-TECS 81	145.	What is hand tapping?
V-TECS 81	146.	What are the names of the three taps of a set?
V-TECS 81	147.	What is a tap drill?
V-TECS 82	148.	What is the correct tap drill for a 3/8 - 16 tap?
V-TECS 82	149.	In what direction does the tap turn?

VII. Operating Grinders

V-TECS 85	150.	Why should air hose not be used to clean machine?
V-TECS 85	151.	If a little grease is good for machine, why wouldn't a large amount be better?
V-TECS 83	152.	Why is the proper balance of a grinding wheel essential?
V-TECS 83	153.	Describe briefly the procedure for balancing a grinding wheel.
V-TECS 87	154.	Explain ring test.
V-TECS 87	155.	Give two reasons for dressing and truing.
V-TECS 89	156.	How many angles and bevels be determined on chisels and punches?
V-TECS 90	157.	Name six angles to be ground on high speed lathe bit.
V-TECS 90	158.	Why should bit be cooled in water while grinding?
V-TECS 88	159.	Define dressing.
V-TECS 88	160.	Define truing.
V-TECS 99	161.	Give three safety precautions when using surface grinders.
V-TECS 99	162.	Give steps in grinding workpiece square on surface grinders.
V-TECS 98	163.	List two advantages of electro-magnetic chuck.
V-TECS 98	164.	What are the three work-holding devices frequently used to hold work for surface grinding?
V-TECS 97	165.	What is the advantage of using a dial indicator to align cylinder grinder?
V-TECS 95	166.	Name two methods of dressing contours and radii on grinding wheels.
V-TECS 84	167.	List precautions while polishing on lathe.
V-TECS 96	168.	____________________ grinding mounts the work between centers and rotates it while it is in contact with grinder's wheel. (Fill in the blank)
V-TECS 96	169.	Name two types of cylindrical grinders.

V-TECS 96 170. Name two types of center type cylindrical grinders.
V-TECS 86 171. Why is cut-off operations with grinding wheel dangerous?
V-TECS 86 172. Give two advantages to cutting off with grinder wheel.

VIII. Operating Power Saws

V-TECS 102 173. Explain method used to check for blade tension.
V-TECS 102 174. In what direction does the blade rotate?
V-TECS 102 175. When and how is the blade lubricated?
V-TECS 108 176. Using the table on page 370 **General Industrial Machine Shop,** what is the cutting speed for general purpose cutting?
V-TECS 108 177. Using the table on page 364 **General Industrial Machine Shop,** what is the feed for general purpose cutting?
V-TECS 103 178. Explain how to cut blade to proper length.
V-TECS 103 179. Explain how to set up welder.
V-TECS 104 180. Explain power saw setup.
V-TECS 104 181. Name three ways to cut with the power saw.
V-TECS 105 182. Obsrve while student installs power hacksaw; observe while student installs metal handsaw. Use checklist for evaluation.
V-TECS 105 183. Explain method used to check for blade tension on power hacksaw and on metal band saw.
V-TECS 105 184. When and how is the blade lubricated on the power hacksaw and on metal band saw?
V-TECS 106 185. In which direction does the bandsaw blade rotate when making internal contours?
V-TECS 106 186. Explain the process of cutting the blade apart and welding the blade back together when making internal contours.
V-TECS 106 187. Explain the method used to check for blade tension on the bandsaw when making internal contours.
V-TECS 107 188. Explain how to mount and align machine guides in the sawing operation to a scribed line.
V-TECS 107 189. Explain how to determine and set cutting speed for sawing to a scribed line.
V-TECS 107 190. Why is it important that scribed lines be clear on a layed-out workpiece before sawing?

IX. Operating Lathes

V-TECS 116 191. What kind of brush should be used to clean the lathe?
V-TECS 116 192. Name four of the main parts in the lathe that should be cleaned.
V-TECS 128 193. What is facing on the lathe?
V-TECS 128 194. Name three ways to mount the workpiece when facing on the lathe.
V-TECS 139 195. When rough cutting a workpiece, how close to the finish size should the piece be turned?
V-TECS 139 196. What is the dog used for when turning between centers on the lathe?
V-TECS 138 197. What does "good finish details" mean?
V-TECS 138 198. What does good finish details depend on when turning a finish cut?
V-TECS 129 199. Give two reasons why workpieces are filed on the lathe.
V-TECS 129 200. What tool is used to clean the file on the lathe?

V-TECS 130	201.	Why would the machine speed be twice the speed of cutting for polishing?
V-TECS 127	202.	Why is the center drill used first when drilling a hole in the lathe?
V-TECS 127	203.	Why would you not steady the drill with your hands?
V-TECS 109	204.	What is the center in the head stock of the lathe called?
V-TECS 109	205.	What is the tail stock center of the lathe called?
V-TECS 145	206.	What is the purpose of the lathe dog?
V-TECS 145	207.	Describe how to align workpiece between centers on the lathe.
V-TECS 132	208.	Give two uses of a knurl.
V-TECS 133	209.	Name two precision tools used to measure precision fits.
V-TECS 110	210.	What is a lathe independent four-jaw chuck?
V-TECS 110	211.	Why is the dial indicator used to line up the workpiece in four-jaw chuck?
V-TECS 112	212.	Why is the workpiece center drilled first before boring a hole with the lathe?
V-TECS 112	213.	Why is the workpiece pilot drilled before boring a hole with a lathe?
V-TECS 118	214.	What are the two functions of the center drill?
V-TECS 117	215.	Name two types of boring tools used in the lathe.
V-TECS 136	216.	Define "reaming".
V-TECS 136	217.	How much smaller should the drill for reaming be?
V-TECS 143	218.	Explain how the size of the tap drill is determined and when is is used.
V-TECS 143	219.	Name the three taps of a set.
V-TECS 123	220.	Name two kinds of tapers used with the lathe.
V-TECS 123	221.	How many degrees is the compound rest required to swivel in order to turn a taper with an included angle of 45° 30'?
V-TECS 124	222.	Name two methods used to measure the tailstock offset.
V-TECS 119	223.	How far out should you engage the feed before starting the cut on an external taper? Why?
V-TECS 121	224.	Why is it necessary to step drill before tapering internal on the lathe?
V-TECS 121	225.	What is the name of the gage used to check internal tapers?
V-TECS 125	226.	Name two types of dies in the machine trade?
V-TECS 125	227.	What is the name of the tool used to hold the die?
V-TECS 126	228.	What are the blades of the automatic die cutter made of that are located on the shaper?
V-TECS 127	229.	Name the tool used to check concave and convex radii.
V-TECS 142	230.	Give definition of convex.
V-TECS 142	231.	Give definition of concave.
V-TECS 113	232.	At what degree is the compound rest set for cutting the screw thread?
V-TECS 113	233.	Explain what is meant by facing the workpice?
V-TECS 113	234.	What is the purpose of a center gage when cutting threads?
V-TECS 114	235.	Define the term "internal".
V-TECS 114	236.	Define the term "external".
V-TECS 114	237.	For cutting internal threads on a lathe, which direction does the compound rest point?
V-TECS 137	238.	Describe the purpose of the center gage in cutting threads on the lathe.

V-TECS 137 239. Describe the purpose of the thread pitch gage when cutting threads on the lathe.

V-TECS 115 240. What should the compound rest be set at when cutting metric "V" threads?

V-TECS 115 241. What is a thread ring gage?

V-TECS 120 242. What should the setting on the compound rest be for cutting an Acme thread?

V-TECS 120 243. How many thousandths should the compound rest advance inward for each cut of Acme Threading?

V-TECS 122 244. When cutting double threads on the lathe, how far apart are the cuts?

V-TECS 122 245. When cutting triple threads on the lathe, how far apart are the cuts?

V-TECS 144 246. Explain the function of the steady rest.

V-TECS 144 247. Explain the function of the follower rest.

V-TECS 134 248. What does the cobalt in the carbide tools do to them?

V-TECS 131 249. What should be the lathe speed for grinding with tool post grinder?

V-TECS 131 250. What should be the lathe feed for grinding with tool post grinder?

V-TECS 111 251. Name at least one method of mounting the workpiece to the face plate of the lathe.

V-TECS 111 252. Why is the dial indicator used to align workpiece on face plate of the lathe?

V-TECS 140 253. What is the purpose of the turret lathe?

V-TECS 140 254. What are the two types of turret lathes?

V-TECS 141 255. Give two methods of mounting work to be spun in the lathe.

X. Operating Milling Machines

V-TECS 151 256. Why should the milling machine be cleaned after each use?

V-TECS 151 257. How often should the milling machine be checked for oil levels and greasing?

V-TECS 151 258. Why should ghe gibs be adjusted in the table and on the column?

V-TECS 147 259. What happens when the milling head is not aligned properly, vertically or horizontally?

V-TECS 147 260. How many locations on the milling table should register the exact reading on the dial indicator when spindle is turned 180°?

V-TECS 175 261. Why is it essential to place the first finished side of workpiece against the fixed jaw of vise on the milling machine?

V-TECS 175 262. After making second cut, what is placed in vise under workpiece to keep it off the bottom of vise?

V-TECS 148 263. What is the most common instrument used in aligning the head or vertical attachments on the milling machine?

V-TECS 148 264. Why is it essential that the attachment be aligned to a zero tolerance in parallel with milling table?

V-TECS 149 265. How is the dial indicator used in aligning fixtures on the milling machine?

V-TECS 149 266. What part of vise should be indicated when setting up vise on milling machine?

V-TECS 146 267. Explain the use of the dial indicator in aligning the workpiece on the milling machine.

V-TECS 153 268. Why is an edgefinder used in the drilling operation on the milling machine?

V-TECS 153 269. How are hole distances found when drilling more than one hole on the milling machine?

V-TECS 174 270. Why is it necessary to drill the hole undersized when reaming on the milling machine?

V-TECS 174 271. Why is the drilling speed reduced by at least half when reaming the hole to size on the milling machine?

V-TECS 172 272. When cutting workpiece with end mill, should the end mill be fed into or away from the workpiece? Explain.

V-TECS 172 273. Which is the stronger tooth construciton, the two lipped or the four lipped end mill?

V-TECS 159 274. How are the holes located on workpiece on the milling machine?

V-TECS 159 275. What instrument is used, along with the centerfinder, to assure accurate centers on workpiece in the milling machine?

V-TECS 160 276. How do you know when the edgefinder locates the true center of the workpiece on the milling machine table?

V-TECS 160 277. How far does the handwheel travel when indicator is moved 180° by rotating the spindle of the milling machine?

V-TECS 166 278. What is the proper way of setting up a vertical attachment to the milling machine?

V-TECS 166 279. Give three ways to determine the correct angle on the vertical attachment.

V-TECS 161 280. How is the centerline of workpiece located for cutting external keyway in the milling machine?

V-TECS 161 281. How is the depth of a keyway determined in a milling machine?

V-TECS 165 282. List the five steps in proper sequence for setting up a workpiece in V-blocks on the milling machine.

V-TECS 165 283. Why should the clamping device be set as close to the workpiece as possible when milling?

V-TECS 155 284. Describe a fly cutter on the milling machine?

V-TECS 155 285. What are the advantages of using a fly cutter in the milling machine?

V-TECS 155 286. How are formed shapes cut on the milling machine?

V-TECS 156 287. How is the workpiece checked to assure that it is within tolerance?

V-TECS 157 288. What is meant by form milling?

V-TECS 157 289. Name at least three items that form cutters are essential in their manufacturing process.

V-TECS 150 290. List the procedure for boring holes on the milling machine, after the workpiece has been indicated and secured in workholding device.

V-TECS 150 291. What increments is the dial on the offset boring head divided?

V-TECS 158 292. Name four or more tools used in setting up a workpiece on the milling machine for jig boring.

V-TECS 158 293. Why is the workpiece center drilled before using the finish drill size on the milling machine?

V-TECS 163 294. Give a brief explanation of centering cutter to machine Woodruff keyway on milling machine.

V-TECS 163 295. How is the depth of a Woodruff keyway determined on the milling machine?

V-TECS 167 296. What are the two most important attachments used in angular milling?

V-TECS 167 297. Why is the sine bar and gage blocks used in milling an angular surface?

V-TECS 168 298. Name three operations that can be performed with the rotary table.

V-TECS 168 299. Rotary tables can be equipped for accurate indexing just like dividing heads. TRUE or FALSE

V-TECS 169 300. Name the types of feeds and controls available on a rotary table.

V-TECS 169 301. Another name for the rotary table is ____________________ ______________ __________________.

V-TECS 173 302. What are the three most common uses of the dividing head on the milling machine?

V-TECS 173 303. What are the two most used index plates on the index or dividing head?

V-TECS 170 304. Name the four most important attachments used in the cutting of gears on a milling machine.

V-TECS 170 305. Explain the meaning of proper clearance when setting up the gear blank for cutting.

V-TECS 171 306. What are carbide cutters?

V-TECS 171 307. Give at least one advantage and one disadvantage of using carbide cutters on the milling machine.

V-TECS 164 308. What is meant by straddle milling?

V-TECS 164 309. What determines the width of workpiece when performing the straddle milling operation on the milling machine?

V-TECS 152 310. What type cutter is used in cut-off operations on milling machine?

V-TECS 152 311. Why is it important to cut as close to workholding device as possible?

V-TECS 162 312. Why is the setting of the stroke of the slotter the most important step in using the slotting attachment on the milling machine?

V-TECS 162 313. Does the slotting attachment operate in a circular motion or a reciprocating motion?

V-TECS 154 314. What is the tracing stylus' function in profile milling on the milling machine?

V-TECS 154 315. What is profile milling?

XI. Operating Shapers

V-TECS 176 316. Should all oil cups on the shaper be filled?

V-TECS 176 317. When and how should the shaper be cleaned?

V-TECS 181 318. Identify the cutting speed of the shaper.

V-TECS 181 319. What is the amount of feed based on for the shaper?

V-TECS 179 320. Define the length of stroke for machining a flat surface on shaper.

V-TECS 179 321. Explain how to mount workpiece in vise when machining flat surface on shaper.

V-TECS 177 322. Explain the down feed of the shaper cutter.

V-TECS 177 323. Explain cutting tool overhang of the shaper.

V-TECS 178 324. Name three ways to make angle cuts on the shaper.

V-TECS 180 325. The amount of feed per cut in machining a keyway on shaper is based on ____________________. (Complete the statement)

V-TECS 180 326. How much should be taken off each cut to machine keyway on shaper?

XII. Welding

V-TECS 182 327. Identify the digits in the electrode classification number E-6013.

V-TECS 182 328. Identify the letters in these abbreviations: DCSP and DCRP.

V-tECS 182 329. Which polarity produces the deepest penetration?

V-TECS 183 330. List the main constituents of brass.

V-TECS 183 331. What might cause a coppery appearance in some brazed joints?

V-TECS 183 332. Why is proper size tip important?

V-TECS 184 333. Name two advantages of cutting metal with oxyacetylene torch.

V-TECS 184 334. Why are welding hoses colored?

V-TECS 184 335. Why are regulators used?

V-TECS 189 336. What is meant by undercutting a welded joint?

V-TECS 189 337. Why should cylinder valves be opened slowly?

V-TECS 189 338. Where is the hottest part of the flame?

V-TECS 188 339. What is the purpose of the flux?

V-TECS 188 340. What metals are contained in silver solder?

V-TECS 187 341. Why should the thickness of weld be measured periodically?

V-TECS 187 342. Why should slag inclusions be avoided?

V-TECS 185 343. Why is helium used in heliarc welds?

V-TECS 186 344. Name three materials used as electrodes.

V-TECS 186 345. Why should electrode never touch workpiece?

V-TECS 186 346. What shapes may be machined using EDM?

XIII. Performing Heat Treatment Tasks

V-TECS 191 347. List the steps involved in hardening steel.

V-TECS 191 348. What determines the degree of hardness obtainable in alloy steels through heat treatment?

V-TECS 191 349. List three hardness number systems.

V-TECS 191 350. What are the most commonly used Rockwell hardness scales?

V-TECS 190 351. What is the purpose for annealing?

V-TECS 190 352. Explain the full annealing process for medium carbon steel.

V-TECS 192 353. What is meant by stress?

V-TECS 192 354. List three general types of stress which may be applied to a structural member.

XIV. Performing Numerical Controlled Machines

V-TECS 193 355. Explain the difference between absolute and incremental dimensioning.

V-TECS 193 356. Explain the difference between the part reference point and the machine table reference point. From which point must all tool movements be measured?

V-TECS 193	357.	In incremental programming, what symbol is used to indicate a move in the negative direction?
V-TECS 197	358.	What is the first consideration given when writing a program for numerical controlled machines? Explain.
V-TECS 197	359.	What is always the first step in writing a program?
V-TECS 196	360.	Give the steps or procedure for transferring the drawing to tape for the numerical controlled machine.
V-TECS 196	361.	What purpose is G-code numbers used in N/C programming?
V-TECS 195	362.	What is the most important rule when setting up a numerical controlled machine for machining?
V-TECS 195	363.	Give the procedure for checking the machine before starting the first cut.
V-TECS 194	364.	Name at least two reasons that would cause workpiece to be out of tolerance even though the program is correct in numerical controlled machine.
V-TECS 194	365.	Give the potential advantages of using N/C machines.

ANSWERS FOR EVALUATION QUESTIONS

I. Safety
  1. a. No horseplay
     b. Good housekeeping
     c. Use safety glasses and equipment
     d. Know how to use first aid to help another worker
     e. Know proper use of fire extinguishers
     f. Identify color standards for fire extinguishers (electrical and gas)
  2. Safety Examination Answers
     1. a. Always wear safety glasses
        b. Use proper tools for work to be performed
        c. Never abuse tools
        d. Check tools for defects before starting to work
        e. Keep hands away from sharp cutting edges, such as sheared edges, cutting with cold chisel, etc.
        f. Keep work area clean and uncluttered
     2. Clothes that do not hang loose, that could catch in rotating equipment.
     3. At all times
     4. With a brush or hook "never with bare hands."
     5. To insure a firm grip so the hammer will not slip out of your hands.
     6. Cut off all electrical power and lock out switches to make sure power is not turned on accidentally.
     7. On a vise secured to table, never in the hand.
     8. a. Check wheel for damage
        b. Check rpm rating for safety
        c. Wear safety glasses or face shield
        d. Make sure work is secured in place.
     9. Keeping shop clean and orderly, all objects off floor, no grease on floor and machine free of dirt and metal chips.
     10. A person could be seriously injured by being pushed or running into moving equipment. Never allow horseplay in the shop.

II. Performing Mathematical Calculations
  3. Calculating cutting speed: $CS = \frac{\pi \times DN}{12}$
     D = Diameter of cutter in inches
     N = RPM
     Calculating feed: F = R x T x RPM
     F = Feed rate in inches per minute
     R = Feed per revolutions of tooth per revolutions
     T = number of teeth
  4. a. .6875
     b. .125
     c. .5937
     d. .3125
     e. .0937

5. Instructor must review the completed Bill of Materials for proper placement of information.

6. Taper per inch: $T = \frac{(D-d)}{L}$

Taper per foot: $tpf = \frac{\text{large diameter - small diameter}}{\text{length of taper (in.)}} \times 12$

7. Offset tailstock: $\text{Offset} = \frac{\text{tpf} \times \text{total length (in.)}}{24}$

8. a. Outside diameter of gear blank

Use formula: $OD = \frac{N + 2}{P}$

O D = Outside diameter
N = Number of teeth
P = Diametral pitch

b. Depth of tooth

Use formula: $d = \frac{2.157}{p}$

d = Depth of tooth
p = Diametrial pitch

c. Tooth thickness

Use formula: $t = \frac{1.5108}{p}$

t = Tooth thickness
p = Diametrial pitch

d. Addendum

Use formula: $a = \frac{1.0}{p}$

a = addendum
p = diametrial pitch

e. Chordal addendum

Use formula: $ca = a + \frac{t^2}{4D}$

ca = Chordal addendum
a = Addendum
t = Tooth thickness
D = Outside diameter

f. Chordal thickness

Use formula: $ct = D \sin \frac{(90)}{N}$

ct = Chordal thickness
D = Outside diameter
N = Number of teeth

9. Tap drill size .750 $= \frac{.0129 \times 80}{10}$

10. $\frac{3.1416 \times 8'' \times 5000}{12} = 10{,}486.66$

11. The 40-1 ratio and the 5-1 ratio

12. A worm wheel attached to the spindle of the index head and moved through a worm. The worm is keyed to a shaft to which a crank is attached. One complete revolution of the crank causes any one tooth on the worm gear to make a complete revolution. Forty turns of the crank are required to turn the spindle one full revolution.

13. Tolerance is the total permissable variation of a size. It is the difference between the maximum and minimum limits of size.
14. Allowance is an intentional difference between the maximum material size limits of mating parts. It is the minimum clearance (positive allowance) or maximum interference (negative allowance) between mating parts.
15. Depth micrometer -- vernier caliper
16. Tap dead center

III. Designing and Planning Machine Work

17. Instructor must check for accuracy.
18. a. Missing dimension is a. 2 1/4 and b. 5/8.
    b. Blueprint footnotes identify tolerances, scale of drawing, type of metal and any other related performances on the blueprint. On the given blueprint, the following are defined:
    MATERIAL -- Type of metal
    HEAT TREATMENT -- Hardening or annealing
    BASE -- Part of workpiece being fabricated
    BORING BAR HOLDER -- Part of workpiece being fabricated
    NO. REQUIRED -- Number of pieces required
    SCALE -- Full size of workpiece
    DESCRIPTION -- Tolerances permitted
19. To specify dimensions and tolerances so that the student or worker has a clear understanding of the procedures.
20. See lesson for drawings.
21. a. Method of shipping and receiving
    b. Time limitations
    c. Dimensions and tolerances

IV. Perfoming Precision Measurement

22. a. Clean with solvent
    b. Polish with crocus cloth
    c. Check for blemishes, scratches and misalignment
    d. Oil with light machine oil (not motor oil)
    e. Store in cases, tool boxes, etc.
23. Non-precision
24. Error in measurement due to observing rule graduations at an angle other than 90° or 0°.
25. Rules become worn or blurred at the ends.
26. Slide caliper rule can be set to a specific size for repeated measurements.
27. Regular use as a working tool would cause undue wear and scratches and make it lose its precision.
28. a. Blade or rule
    b. Square head
    c. Center head
    d. Protractor head
29. Dial calipers are accurate to 0.001; spring calipers' accuracy depend on instruments used to determine units of measurement.
30. Hermaphrodite calipers
31. a. Layout work and inspection
    b. Used as template for grinding lathe bits and forming tools.

32. The vernier mechanically divides 1 graduation by 10 to allow mikes to read to .0001".
33. Read the micrometer as a standad micrometer then note the line on the vernier scale that coincides with a line on the thimble.
34. Use 2" gage block or standard and observe that 0 on thimble coincides with index line on sleeve.
35. Metric mikes are accurate to millimeter.
    Inch mikes are accurate to 0.0001".
36. a. Millimeter
    b. .5 millimeter
    c. .01 millimeter
37. The thimble nut is adjusted to a tighter fit on the spindle thread to prevent a change in setting when removing from workpiece.
38. a. Make sure rod (spindle) is in place and cap tightens properly.
    b. Make sure inside micrometer is in alignment with measurement being made.
39. The correct "feel" will have "drag" without binding.
40. The wire size that will give the most accurate measurement using the three-wire method.
41. Calculate G (wire size)

$$G = \frac{.57735}{10}$$

$$G = .0577$$

Calculate M (measurement over the wires)

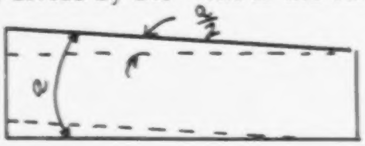
$$M = D + 3G - \frac{1.5155}{N}$$

$$M = .75 + (3 \times .0577) - \frac{1.5155}{10}$$

$$M = .7715$$

42. Vernier depth gage is accurate to .001" while rule depth gage is accurate to 1/64".
43. Controlled by nut on end of extension rod.
44. Remove burrs
45. a. Remove burrs
    b. Hold the micrometer base firmly against the surface of workpiece
    c. Rotate thimble until rod touches bottom
    d. Recheck the micrometer setting, take reading.
46. Read in reverse order.
47. a. The vernier scale on the movable jaw has 25 equal divisions, each representing .001".
    b. The 50 division vernier has 50 divisions which represents .001".
48. a. The last large number above the main scale on the bar and to the left of the vernier scale represents the number of whole inches.
    b. Note the last small number on the bar to the left of the zero on the vernier scale. Multiple this number by .100.
    c. Note how many graduations are showing on the bar between the last number and the zero on the vernier scale. Multiple this number by .025.
    d. Observe which line on the vernier scale coincides with a line on the bar. Multiple this number by .001.

49. Optical comparators project an enlarged shadow onto a screen where it may be compared to lines or a master form.
50. Large amplification permits extremely accurate gauging to be performed even on very small parts.
51. Optical comparators are a fast and accurate means of measuring small, odd-shaped parts which are difficult to measure otherwise.
52. Charts are available in several magnifications, therefore, care must be taken to use a chart of the same magnification as the lens mounted on the comparator.
53. Consists of steel bar with two cylinders of equal diameter secured near the ends. The bar becomes the hypotenuse of a right triangle.
54. All 5" sine bars are 5" ± .0002 between centers with face ±.00005" within 5". All 10" sine bars are 10" ± .00025 between centers with face ±.00005" within 10".
55. Build-up $= 5 \times \sin 30^{\circ}$
$= 5 \times .500$
$= 2.500$
56. In order to take 1/2 of a included angle given as TPF which has already been multiplied by 12, divide by 24. This is the same as dividing original tangent by 2.



57. By "wringing" to make them stay together
58. a. To check the dimensional accuracy of fixed gauges
    b. To calibrate adjustable gages
    c. To set comparators
    d. To set sine bars
    e. Precision layout and tool setups
59. To prevent wear from occuring on all the blocks
60. Put wear blocks on outside of ALL setups
61. Master set used as standard, working set used in shop
62. Handle them only when necessary for short periods of time
63. Clean and oil each time they are used.
64. Provides reference plane for layout, setup, and inspection work.
65. Pink, black, or grey (natural elements in each determine type and color)
66. The advantages of granite are:
    a. They do not rust
    b. They do not burr
    c. They are non-magnetic
    d. They are not appreciably affected by temperature
    e. Abrasives do not embed themselves in granite as easily.
67. a. Keep clean
    b. Protect with cover when not in use
    c. Do not strike with hammer or center punch workpiece on them
    d. Deburr workpiece
    e. Slide heavy workpieces onto surface plate rather than placing directly on.

68. Variation in flatness from corner to corner in ten thousandth of an inch.
69. Height gage has a scale graduated to .001".
    Surface gage is dependent on other measuring devices to obtain a reading.
70. By using rules, squares or duplications and/or transferring other measurements.
71. Dial indicator has greater range than dial test indicators and sometimes has a continuous-reading scale.
72. Regular range indicators are equipped with plus-minus balanced type dial.
73. Perpendicular has spindle at right angles to dial.
    Universal dial test indicator has contact point that may be set at several positions through 180° arc.
74. Make measurement and compare with micrometer measurement.
75. a. Marking location dimensions
    b. Making direct measurements
76. Dial indicator and surface plate
77. a. 2.985 not in location

$$\begin{array}{r} 1.00'' \\ +\ \ .375'' \\ \hline 1.375'' \end{array} \qquad \begin{array}{r} 4.360'' \\ -2.985'' \\ \hline 2.985'' \end{array}$$

    c. 7.430 correct location
    d. 1.786 not in location
    e. 4.838 not in location
78. Quicker and less clumsy
79. Initial reading plus half the distance of the hole
80. Quick means of inspecting and checking a specific measurement.
81. 1/10 the tolerance they are designed to control.
82. GO end = 1.748; NO-GO end = 1.752
83. Stamped GO or NO-GO and sometimes a groove will be cut near "NO-GO" end.
84. Do not force or turn it.
85. a. Measure the hole size and select the proper gauge
    b. Clean the gauge and the hole
    c. Depress the plungers until slightly smaller than the hole diameter and clamp them into position
    d. Insert it into the hole and with the handle tilted upwards slightly, release the plungers.
    e. "Lightly" snug up the knurled knob.
    f. Hold the bottom leg of the telescope gauge in position with one hand.
    g. Move the handle downwards through the center while slightly moving the top leg from side to side.
    h. Tighten the plungers: check the "feel"
    i. Check size with outside micrometers.
86. Grooves, pits and taper
87. .001

V. Performing Benchwork

88. Footwear, eye protection, head protection, ear protection.
89. If unsafe conditions are left unreported, a serious accident could take place.

90. a. Use tool for intended purpose for which it was designed.
    b. Keep clean and oiled and stored in tool box.
91. a. Coarse pitch
    b. Fine pitch
    c. Medium pitch
92. Rough, coarse, bastard, second cut, smooth and dead smooth
93. Avoid applying too much pressure
94. a. Do not store where they will rub together.
    b. Do not knock file on vise or other metallic object.
    c. Use file card to clean file.
    d. Do not use files for prying.
95. A prick punch has a keen point and is used for layout.
    A center punch has a 60° point and is used to start drill bits.
96. a. Hold drill with both hands.
    b. Make sure drill is properly grounded.
97. The correct size drill used in making hole to be tapped.
98. a. Tapered (starting)
    b. Plug
    c. Bottoming
99. Adjustable split die
100. Reamers should be turned the same way to prevent keen edges from being chipped.
101. a. Wear safety glasses or goggles.
    b. Make sure guards are in place.
102. The weight causes the ball penetrator to depress metal, the more penetration the softer the metal.
103. A file test indicates that the workpiece is softer or harder than the file.
104. To withstand the pressure of workpiece.
105. a. Wear goggles
    b. Check wheels to be sure they are rated to run no faster than grinder speeds.
106. Broaches will machine almost any irregular shape parallel to broaching axis.
107. Transfer punches and screws are faster and more convenient than tedious layout of pattern.
108. Tapered reamers
109. The EDM burns top out and leaves hole the same dimension.
110. If it is turned the wrong way the screw will continue to tighten.
111. To make sure of using the correct specifications in making repairs.
112. To prevent extensive damage if adjustments are incorrect. (Breaking in process)
113. High spots can be seen easily.
114. Test dial indicator
115. Taps are harder than the drill bits used to remove broken parts. Therefore, taps should be annealed to make them softer before drilling.
116. Prevents excessive wear in one spot.
117. To restore stripped threads to original standard.
118. Hitting with hammer will cause pulley to warp, crack, or break.
119. Check size often with bore gage or other appropriate measuring tool.
120. To keep metal particles from clogging abrasive of which whet stone is made.
121. The arbor press uses the mechanical advantage of a rack and pinion to multiply the leverage applied.

VI. Operating Drill Presses

122. The surface of the drill press should be cleaned to prevent the work from being unlevel.
123. A hair brush and cloth rag should be used to clean the drill press table.
124. The decimal equivalent of the 1/2 inch drill is .500.
125. The purpose of countersinking a drilled hole is to accommodate the head of a flat head machine screw.
126. The included angle of a counter sink is 82°.
127. A counterbore is used when the head of a bolt needs to be inset the depth of the head.
128. Spot facing is the process of making circular flat spots on the face of a workpiece.
129. Tools used in spotfacing operations are: grinding compound, polished metal, drill press and a wood dowel pin.
130. The drill press with automatic feed should be lubricated each time it is used.
131. The drill jig is used to hold parts being drilled.
132. A drill jig furnishes a guide for drilling a hole accurately.
133. Lapping a hole to size is a process used to take very small amounts out of a drilled hole with use of abrasive.
134. V-blocks are designed to hold firm, round stocks.
135. V-blocks are used to hole the work piece firm and in place when setting up to drill the work piece.
136. Reaming is the process of making drilled holes smooth and accurate.
137. Hand reaming is done by hand and on a bench. Power reaming may be performed on a drill press, lathe, turret lathe, or on a milling machine.
138. Reamers are classified as hand reamers and power reamers.
139. If the cutting edges were different in length the size of the hole would vary.
140. As the drills get small the webb gets thicker. This means the point would be hard to fit in a center punch mark.
141. If the cutting edges differ in the angle with the center point of the drill, this would make the drill chip or break.
142. Twist drills can be sharpened by free hand grinding or by a drill pointing machine.
143. A drill grinding gage can be used to check lip clearance on drills.
144. The "T" tap wrench and the tap handle are tools used when tapping holes.
145. Hand tapping is the process of putting thread internal.
146. The three taps of a set are: taper, plug, bottoming.
147. The tap drill is a drill used to create a hole that is to be tapped.
148. The 3/8 - 16 threads per inch tap drill is a 5/16 inch drill.
149. All right hand taps turn to the right or clockwise.

VII. Operating Grinders

150. Air pressure may force grit into bearings and blow grit in worker's eyes.
151. Excess grease may short out electrical motors and bearing surface can only hold a certain amount; excess is wasted.
152. To eliminate vibration and chatter.

153. a. Mount wheel and adaptor on surface grinder and true wheel.
  b. Remove wheel and mount on tapered arbor and place on balancing stand.
  c. Allow wheel to rotate until it stops, mark heavy point with chalk.
  d. Loosen balancing wheel weights and move to point opposite chalk mark.
  e. Repeat until balanced.

154. Vitrified or silicate wheel will give a metallic ring sound if they are sound, cracked wheel will not ring.

155. a. Dressing makes wheel cut better by exposing sharp abrasive particles.
  b. Wheel will grind with maximum surface contact without vibration.

156. Use vernier protractor or protractor head on combination set.

157. Side cutting edge angle, end cutting edge angle, end relief angle, side relief angle, back rake angle, side rake angle

158. To prevent overheating which may remove temper.

159. The operation of removing the dull grains and metal particles from grinder wheel with wheel dresser.

160. Truing a wheel is the operation of removing high spots on wheel to make it concentric to spindle.

161. a. Always wear safety glasses
  b. Ring test wheel before mounting
  c. When starting grind, stand to one side and make sure no one is in line with grinding wheel in case of breakage.

162. a. Mount workpiece properly on magnetic chuck
  b. Set table traverse dogs to allow 1/2 inch more clearance on each end of table travel
  c. Lower wheel head to work until it sparks on highest point of workpiece
  d. Grind flat by lowering wheel-head .0005 to .001 each cut
  e. When first surface is flat, grind opposite surface
  f. Grind third surface flat; then check with precision square
  g. Make adjustment if necessary using shims
  h. Grind opposite (4th side) side
  i. Accept, reject or rework until square

163. a. May be cut on and off with switch.
  b. Holding power may be varied according to thickness of work.

164. Vise, permanent magnetic chuck, and electro-magnetic chuck.

165. It is the most accurate method to adjust taper out of grinders.

166. Radius wheel dresser and crush form dressing

167. a. Move polishing cloth slowly back and forth along work.
  b. Hold cloth with one hand; apply pressure with the other.
  c. Keep hands clear of chuck.

168. Cylindrical

169. Center type and centerless

170. Plain and universal

171. Wheels are thin, therefore, side pressure will cause them to shatter.

172. a. Hard, difficult to cut metal can be parted with grinder wheels.
  b. Remaining surface is smooth and straight.

VIII. Operating Power Saws

173. Blade tension is checked by setting the blade tension gauge to proper setting.
174. Blade always rotates with teeth running toward stock.
175. Blade is lubricated by automatic oiler as soon as machine is turned on.
176. 150-175 RPM
177. Moderate
178. Blade should be measured from end to end plus enough stock to square each end.
179. Square both ends of blade, butt up to back of welder letting the ends of the blade touch each other.
180. Workpiece should be held firm in vise. Guideline should be drawn on workpiece, select proper blade, then start saw. Advance blade against workpiece.
181. Cut off, straight sawing and contour
182. a. Check list for installing power hacksaw:
    _____ Select saw blade
    _____ Cut off electrical power
    _____ Release tension clamp
    _____ Remove and store old blade
    _____ Adjust for length of new blade
    _____ Insert new blade in fram
    _____ Insure that teeth point in direction of cut to be done
    _____ Tighten blade in the frame

    b. Check list for installing metal band saw:
    _____ Select saw blade
    _____ Cut off electrical power
    _____ Release tension on blade
    _____ Remove blade
    _____ Loop blade for storage
    _____ Check guides and remove and install new guides according to operator's manual
    _____ Unwind new blade
    _____ Install new blade
    _____ Apply tension to blade according to operator's manual and inspect for blade direction and guide seating
183. Blade should be tightened to proper tension setting on gauge. Also when sound comes from blade when plucked like a guitar string in tune.
184. Blade should be lubricated on contact of blade to the stock through an automatic oiler.
185. Blade pressure will be down toward the table.
186. Blade will be cut and placed through a drilled hole in the stock. Blade will then be welded together and mounted back on the machine.
187. Blade will be tightened until tension dial reads proper setting.
188. Guides should be opened on slide bar wide enough to accommodate stock diameter.
189. The thickness of the steel being cut would determine cutting speed for saw.
190. This is to assure precision cutting.

IX. Operating Lathes

191. A stiff bristled brush should be used to clean parts of the lathe.
192. The main parts of the lathe to be cleaned are:
    a. Ways
    b. Spindle threads
    c. Thread of chuck
    d. Spindle hole
193. Facing is the operation of cutting the end face of a section at right angles to the axis of the workpiece.
194. a. In a chuck
    b. On a mandrel
    c. In a collet
195. When rough cutting, the size is left to about 1/32" over finish size for finishing.
196. The dog drives the workpiece between centers on the lathe.
197. "Good finish details" means machining a surface to accurate size with a fine, smooth finish.
198. Good finish details depends on the right tool, correct feed and speed, and set of tools in tool post.
199. Workpieces are filed on lathe to remove burrs and sharp edges and to prepare surface for polishing.
200. The file card is used to clean the file.
201. The polishing speed should be twice the cutting speed to give a high gloss finish.
202. By center drilling the workpiece first, the drill will penetrate straight.
203. The drill could break and cause injury to the operator.
204. The head stock center is called a live center.
205. The tailstock center is called a dead center.
206. The lathe dog give the work its drive.
207. Proper use of dial indicator and test bar on workpiece between the centers will assure a precision cut.
208. Knurls are used for ornament and for hand grip.
209. The micrometer and the vernier caliper are used to measure precision fits.
210. An independent four jaw chuck is a chuck in which each jaw moves separately.
211. Using the dial indicator with the four jaw chuck will align the work precisely.
212. By center drilling the workpiece first, all boring tools will be in the center of work and be true.
213. The workpiece is pilot drilled first so that the boring tools will have a guide to follow.
214. The center drill is used as a pilot drill or a countersink.
215. Two types of boring tools are the recess boring cutter and the regular boring bar.
216. Reaming is making an existing hole smoother and more accurate.
217. The drilled hole should never be any smaller than .015 under reamer size.
218. The tap drill is a drill which is smaller in diameter than the tap to be used. The tap drill is used first.
219. The starter, plug, and bottoming taps are in the three-tap set.

220. Two kinds of tapers used in the shaop are: Morse standard and Jarno standard.
221. Solution:

$$\text{Angle with centerline} = \frac{\text{included angle}}{2}$$

$$= \frac{45^\circ \; 30'}{2} = 22^\circ \, 45'$$

222. Measuring tailstock set over with a scale and the tailstock set off center lines are used to measure the tailstock offset.
223. The feed should be engaged at least 1/2" before starting cut. By engaging the feed 1/2" before starting cut, the possibility of a backlash is eliminated.
224. It is necessary to step drill to get the diameter of the small end (one closer to chuck) accurate.
225. A taper plug gage is used to check internal tapers being cut.
226. The adjustable and solid dies are two types of dies used in the machine trade.
227. The die stock is used to hold the die.
228. The blades of the automatic die cutter are made of carbon steel and high speed steel.
229. The radius gages are used to check concave and convex radii on corners or against shoulders.
230. Convex is having a surface that curves outward like the surface of a sphere.
231. Concave is having a surface that curves inward like the inside section of a sphere, the hollowed-out part.
232. The compound rest is always set at 29° for cutting screw threads.
233. Facing is making the ends of the workpiece square and true.
234. The center gage is used to align threading tool for cutting threads.
235. Internal means inside.
236. External means outside.
237. The compound rest points in the direction of the cutting angle.
238. The center gage is used to align tool bit at a 90° angle off of work center.
239. The thread pitch gage identifies the number of thread per inch and the pitch of the threads.
240. The compound rest should be set at 29° when cutting metric "V" threads.
241. The thread ring gage is a gage used to check the finish thread.
242. For Acme thread cutting the compound rest is set at 14 1/2°.
243. For each cut on the Acme thread, advance inward .003 for each cut.
244. When cutting double threads the cuts are 180° apart.
245. When cutting triple threads, the cuts are 120° apart.
246. The steady rest is used for supporting long workpieces when being cut or threaded.
247. The follower rest supports a long workpiece and prevents it from springing away from the tool during operation.
248. The cobalt in the tool bits makes them tougher and more wear resistant.

249. When using tool post grinder the lathe speed should be 80-100 rpm.
250. Lathe feed should be .005 to .007 when using tool post grinder.
251. The workpiece can be mounted to the face plate by using bolts or straps.
252. The dial indicator is the more accurate method of aligning the workpiece.
253. The turret lathe is an indexing-tool machine used to machine identical parts to a close tolerance on a production basis.
254. Two types of turret lathe are ram and saddle.
255. The two methods of spinning work are mounting in the chuck and mounting between centers.

X. Operating Milling Machines

256. Dirt and foreign matter wears out the metal surfaces of the milling machine causing inaccurate machining and irrepairable damage to machine.
257. Everyday or before each use.
258. To remove lost motion or retain accuracy and rigidity when cutting with the machine.
259. The cutter will leave a slight concave surface in the workpiece, therefore, if several cuts are taken the workpiece will be uneven.
260. Three places. If table is level it will not change the dial indicator readings.
261. The fixed jaw has been indicated square and true to head and table of milling machine, therefore there is less room for inaccuracy.
262. Two identical strips of metal called parallels to allow only a small area of workpiece to touch vise for ease in checking for flatness and squareness.
263. Dial indicator
264. Work performed in the milling machine will not be accurate if head is not parallel to table.
265. To align fixtures on the milling machine, they are moved longitudinally along fixed jaw of vise to check for accuracy using the graduated dial on the dial indicator. (The dial is graduated in .001 increments.)
266. Fixed jaw
267. The dial indicator is graduated in .001 inches and set on one end of workpiece. By moving longitudinally, the indicator travels from end to end and shows amount of runout of workpiece.
268. To determine the exact location from the edge of workpiece to center of hole.
269. By using the graduated dials to move over to next hole with complete accuracy.
270. To allow enough metal to be removed for finishing to specified size of reamer.
271. To reduce excessive overheating and wear on reamer.
272. The mill cutter should always be fed into workpiece in direction of cutter rotation. If fed in opposite direction workpiece is going away from cutter, causing a climbing effect which can cause cutter to grab or dig into workpiece causing cutter to break, damage workpiece, and may cause serious injury to operator.
273. The two lipped end mill is stronger as the body is thicker.

274. Centerfinder, or wiggler
275. Dial indicator
276. When the dial indicator attached in the spindle is rotated 180° and the reading on the dial is the same on either side.
277. One half the reading on the dial indicator.
278. Bolt the vertical attachment directly to the column of the horizontal milling machine. The horizontal spindle will drive the vertical head spindle.
279. a. By the graduated dial on the vertical attachment
    b. Square and indicator
    c. Vernier bevel protractor
280. By using an edgefinder or placing a piece of paper between cutter and workpiece.
281. The standard depth of a keyway is one half the width of keystock used in the keyway. (For 1/2" key depth of keyway, it should be 1/4" deep.)
282. a. Clean table
    b. Clean T slots
    c. Wipe all accessories or attachments clean and free of dirt and grease
    d. Mount V-blocks in T slots in milling table
    e. Use the proper clamps and step blocks to keep clamps level with workpiece
283. Clamps that are not secured as close to the work piece as possible may allow the workpiece to move and cause inaccuracy in the measurements.
284. A fly cutter is a tool consisting of one or more single-point tool bits or cutters mounted in a bar or cylinder which is attached to the spindle of the milling machine.
285. A fly cutter can do several operations: mill flat surfaces; cut grooves; cut holes through thin metal; and, since each tool is adjustable individually, holes of several diameters can be bored simultaneously.
286. With fly cutter having a ground shaped cutting tool, called a forming tool.
287. With templates, gages, or optical comparator.
288. Form milling is the shaping of workpiece by means of a cutter ground to the shape or contour desired in finished product.
289. Form cutters are used extensively in the manufacturing of taps, reamers, milling cutters and gears.
290. a. Mount wiggler in spindle
    b. Center spindle of mill over pre-punched hole with wiggler
    c. Center drill workpiece
    d. Drill pilot hole
    e. Drill hole 1/16" to 1/8" smaller than finished size
    f. Mount offset boring head and bore trial cut, check hole for size
    g. Set dial on boring head, using adjustment screw to finish, bore to dimensions
291. In .001 inch
292. Dial indicator; edgefinder; offset boring head; center drill; drills; boring bar
293. If workpiece is not center drilled, the drill bit will lead off center and possibly break, ruin the hole, or cause serious injury.

294. To center the cutter, move the workpiece upward half the diameter plus half the cutter width plus thickness of paper or feeler.
295. Cutters are numbered. Refer to machinist handbook.
296. Angle plate and surface plate
297. To select the correct angle, according to blueprint.
298. Milling curved slots; spacing holes at given angles apart; cutting angular surfaces
299. True
300. Manual feed, power feed, manual control, power control
301. Circular milling attachment
302. Gear cutting, grooves, hexagons and similar operations at specified angular distances apart.
303. Direct index plate or (1) 1:1 ratio -- (2) 40:1 ratio
Ratio meaning -- the index head has 40 teeth on the worm wheel, therefore it takes 40 turns of the crank to make the spindle revolve one complete turn.
304. Dividing head, tailstock, center rest, dog, mandrel, correct cutter, and correct index plates for the dividing head.
305. Proper clearance means the cutter must have enough distance to clear the gear blanks before it strikes the dog that holds the mandrel in position on the dividing head and tailstock.
306. Carbide cutters are made of solid carbide or cemented carbide inserts. A very hard but brittle metal that can endure higher speeds and feeds than conventional milling cutters.
307. Carbide cutters can be operated at a much higher speed; cut harder material than regular cutters; but cannot stand interrupted cuts and sudden impacts.
308. The operation of milling the two opposite sides at the same time.
309. The spacers used to hold the cutters at the correct distance apart.
310. Metal slitting saws with side cutting or staggered teeth
311. To eliminate chatter and to give more stability for protection and longer wear of cutter.
312. If stroke is incorrectly set, the housing of slotter may strike workpiece causing damage to tool, workpiece, and housing of slotter.
313. Reciprocating motion
314. It is connected to the cutting tool by pantograph arm linkage and follows the exact contours that are being duplicated. This causes the tool to exactly duplicate the path of movement.
315. The making of parts using a tracing attachment set up on a pattern of contours and dimensions as part to be made.

XI. Operating Shapers
316. All oil cups should be kept full at all time.
317. The shaper should be cleaned after each use with a hair brush and wiped down with a clean oiled rag.
318. Cutting speed for the shaper is the distance per minute the cutting tool moves over the workpiece.
319. The feed is based on the depth of cut, the cutting speed, and the finish desired on a cut in the shaper.

320. The length of stroke in machining flat surface would be the length of workpiece plus 1/2 inch.
321. When mounting workpiece in the vise for machining flat surface, first use dial indicator to square the vise (on fixed). Then, place paper strips under workpiece. Tap gently with mallet until paper strips are snug.
322. Down feed of the shaper cutter is the direction the cutter is fed to make a cut.
323. Cutting tool overhang on the shaper is the clearance of clapper box from the stock at the beginning cut.
324. Angular cuts may be made by:
    a. Setting cutting edge of the tool at an angle corresponding to the angle to be produced on the workpiece.
    b. By setting workpiece at an angle.
    c. By swiveling the toolhead to guide the tool in an angular direction.
325. The depth of cut and the cutting speed determines the amount of feed to be used when cutting a keyway in the shaper.
326. The correct depth per cut when cutting a keyway in the shaper is six to eight thousandths per cut.

XII. Welding

327. E = electrode
6 = 60,000 #
O = tensil strength
1 = position (to be used)
3 = type of flux coating

328. D = direct
C = current
S = straight
P = polarity

D = direct
C = current
R = reversed
P = polarity

329 DCSP
330. Copper and zinc
331. Some of the zinc may have been burned out due to overheating.
332. Small tips may not provide enough heat for large parts; large tips provide too much heat for thin parts.
333. a. Very fast, portable cutting method
    b. Intricate shapes may be cut
334. A safety precaution to prevent accidentally connecting hoses to wrong tank and to identify oxygen from acetylene.
335. To control gasses at constant working pressure.
336. The parent metal is melted thinner near the weld.
337. To prevent damage to diaphrams
338. In the blue cone
339. Flux produce and maintain a chemically clean surface and excludes oxygen from the molten metal
340. 95% cadmium and 5% silver
341. To ensure sufficient metal for turning to original size.
342. Weld will be weak and voids will appear after shaft is turned.
343. Helium shields the weld from oxygen and improves porosity of molten metal.

344. Copper, carbon, brass
345. It may weld to it and machining will stop.
346. It is best used for odd shapes and difficult metals.

XIII. Performing Heat Treatment Tasks

347. Steps 2-6 in Performance Guide
348. The percentage of carbon in steel not to exceed 1.5%
349. a. Rockwell hardness scale
     b. Brinell
     c. Shore scleroscope
350. "B" and "C"
351. To restore metal to original stage
352. Steps 4 thru 7 in Performance Guide
353. Internal strain or tension, displacing molecules by contraction or compaction.
354. a. Compression
     b. Tensil
     c. Rigidity

XIV. Operating Numerical Controlled Machines

355. Absolute dimensioning is a dimension expressed with respect to origin of a co-ordinate system.
356. a. The machine reference point is the position the tool returns after a complete cycle. The part reference point is the position the part is located for the first machining operation.
     b. The machine reference point.
357. (-x)
358. How the workpiece will be held for machining a setup point should be determined far enough away from the workpiece so that sharp tools do not interfere with loading and unloading the machine.
359. The first line of the program should contain only an EOB code which is necessary for carrying out the rewind stop command given on the next line of the program. The second line of every program should have only a rewind stop code and EOB code.
360. a. Study engineering drawing to determine best sequence of machining operations.
     b. Determine location of part of fixture in relation to zero reference point on machine table.
     c. Determine co-ordinate points.
     d. Determine tool selection, cutting speed and feed rates.
     e. Write program manuscript.
     f. Punch and verify tape for accuracy.
361. G-code numbers are used to signal the N/C machine that a particular mode of operation is required.
362. Always position workpiece on table in relation to zero point or home base on machine table.
363. a. Set all tools in position, if cutting multiple or different sized holes in workpiece.
     b. Make a trial or "dry run" through the complete cycle before allowing tool to touch workpiece.
     c. After trial run, position cutting tools in head and proceed with machining operation.
     d. Check first sequence of machining for accuracy. Re-adjust tool if necessary.

364. a. Dull, worn or abused tools or tool holders
    b. Incorrect feeds and speeds of machine.
    c. Wrong coolant, or lack of coolant can cause excessive heat buildup due to faster feeds and speeds of the N/C machine over conventional machines.

365. a. Accuracy of parts, standard making of part at a faster pace means more production for less expense.
    b. Tape can be used for repeat orders for same parts, therefore eliminating costly jigs and fixtures each time.

APPENDIX E

BIBLIOGRAPHY COMPILED BY SOUTH CAROLINA WRITING TEAM

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